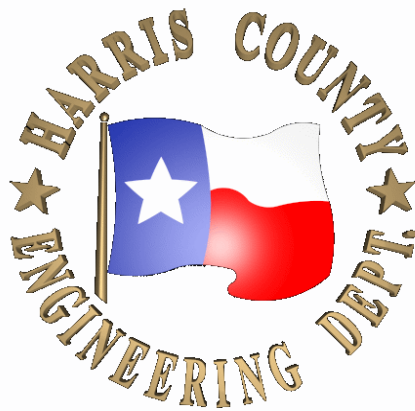


REGULATIONS OF HARRIS COUNTY, TEXAS

FOR

**STORM WATER
QUALITY MANAGEMENT**



AS

**ADOPTED AUGUST 21, 2001
AMENDED SEPTEMBER 25, 2001
EFFECTIVE OCTOBER 1, 2001
AMENDED APRIL 13, 2004
AMENDEND MAY 1, 2011**

**HARRIS COUNTY
PUBLIC INFRASTRUCTURE DEPARTMENT
ENGINEERING DIVISION**

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REGULATIONS OF HARRIS COUNTY, TEXAS FOR STORM WATER QUALITY MANAGEMENT

PART A – GENERAL PROVISIONS

Section 1 – In General

SECTION 1.01 – AUTHORITY

The Commissioners Court of Harris County, Texas adopts these Regulations in its capacity as the governing body of Harris County and the Harris County Flood Control District. The authority of Harris County to adopt these Regulations and the contents hereof is derived from Texas Local Government Code, Section 422, as amended, and these Regulations may be amended at any time by a majority of Commissioners Court as approved by the appropriate federal authorities.

SECTION 1.02 – AREA COVERED BY REGULATIONS

These Regulations apply in all unincorporated areas of Harris County, Texas.

SECTION 1.03 – PURPOSE

The purpose of these Regulations is to provide land use controls necessary to comply with Harris County's NPDES or TPDES storm water permit, to protect human life and health and to avoid increasing pollutant levels associated with storm water.

SECTION 1.04 – CONSTRUCTION OF REGULATIONS

- (a) The Code Construction Act of Texas (Texas Government Code, Chapter 311) applies for construing these rules unless an alternative instruction, definition, or application is contained herein.
- (b) The word "shall" is mandatory and not discretionary as used in these Regulations.
- (c) These Regulations are to be liberally construed to give affect to its purpose and intent.

(d) All terms used in the masculine shall refer to the feminine and vice versa.

SECTION 1.05 – ABROGATION AND GREATER RESTRICTIONS

Except as expressly provided, these Regulations are not intended to repeal, abrogate, or impair any existing laws, regulations, easements, covenants, or deed restrictions. Where these Regulations and other legal requirements conflict or overlap, whichever imposes the more stringent restrictions shall prevail.

SECTION 1.06 – REMEDIES NOT EXCLUSIVE

The remedies listed in these Regulations are not exclusive of any other remedies available under any applicable federal, state, or local law, and it is within the discretion of Harris County to seek cumulative remedies. The suspension, revocation, cancellation, or denial of a SWQ Permit issued under these Regulations shall not prohibit the imposition of any civil or criminal penalty. The imposition of a civil or criminal penalty shall not prohibit any other remedy and shall not prohibit the suspension, revocation, or denial of any SWQ Permit issued under these Regulations.

SECTION 1.07 – ACCESS TO FACILITIES

The County Engineer or his designee, or investigators from Harris County Pollution Control, may enter any building or premises at reasonable times to inspect or investigate conditions relating to water quality or to perform their duties under these Regulations.

SECTION 1.08 – SEVERABILITY

The provisions of these Regulations are severable. If any word, phrase, clause, sentence, section, provision, or part of these Regulations should be invalid or unconstitutional, it shall not affect the validity of the remaining portions and it is hereby declared the intent of the Commissioners Court that these Regulations would have been adopted as to the remaining portions, regardless of the invalidity of any part.

Section 2 – Definitions

The following words and terms, when used in these Regulations, shall have the following meanings, unless the context clearly indicates otherwise.

SECTION 2.01 – ACCESSORY STRUCTURE

“Accessory structure” means a non-commercial structure of the type typically associated with a single-family dwelling unit including, but not limited to, a garage, carport or barn.

SECTION 2.02 – APPLICANT

“Applicant” means the person acquiring a Storm Water Quality Permit.

SECTION 2.03 – AS-BUILT CERTIFICATION

“As-Built Certification” means a form supplied and approved by the County Engineer certifying that Storm Water Quality Features are completed and ready to use.

SECTION 2.04 – BEST MANAGEMENT PRACTICES (BMP)

“Best management practices” or “BMP” means the scheduling of activities and maintenance procedures, the creation of non-structural and structural controls, and other management practices to prevent or reduce pollution discharging into the MS4 and the waters of the United States.

SECTION 2.05 – CERTIFICATE OF COMPLIANCE

“Certificate of Compliance” means a certificate issued by the County Engineer indicating a site complies with the Regulations of Harris County, Texas for Storm Water Quality Management as of a specific date.

SECTION 2.06 – CERTIFICATE OF NON-COMPLIANCE

“Certificate of Non-compliance” means a certificate issued by the County Engineer indicating a site does not comply with the Regulations as of a specific date. The Certificate also advises that legal action may be taken against the property owner. The certificate may be filed in the Real Property Records of Harris County, Texas.

SECTION 2.07 – CERTIFICATE OF PROPER OPERATION

“Certificate of Proper Operation” means a form approved and provided by the County Engineer for the purpose of certifying that the owner or operator of the Storm Water Quality Feature is complying with these Regulations and its Storm Water Quality Management Plan.

SECTION 2.08 – CFR

“CFR” means the Code of Federal Regulations, as it may be amended from time to time.

SECTION 2.09 – CLEAN WATER ACT

“Clean Water Act” means the Federal Water Pollution Control Act, as amended (33 U.S.C. § 1251 *et. seq.*).

SECTION 2.10 – COMMERCIAL USE

“Commercial use” means any profit or not-for-profit activity involving the manufacture, storage, transportation, distribution, exchange or sale of goods or commodities in the provision of professional or nonprofessional services, the sale or lease of real property, or the use of property for multi-family residential purposes.

SECTION 2.11 – COUNTY ENGINEER

“County Engineer” means the holder of the statutory office of County Engineer for Harris County or the employee designated by the County Engineer to perform a task required by these Regulations.

SECTION 2.12 – DEVELOPMENT

“Development” means any man-made change to improved or unimproved real estate including, but not limited to, buildings or other structures, mining, dredging, filling, grading, paving, excavation, drilling operations, or storage of equipment or materials, and any activity that requires a subdivision plat or that is part of a subdivision plat approved by a municipality.

SECTION 2.13 – DISCHARGE

“Discharge” means the introduction or addition of any pollutant, storm water, or any other substance whatsoever into the MS4 or into the waters of the United States, or to cause, suffer, allow, or permit any such introduction or addition.

SECTION 2.14 – DISCHARGER

“Discharger” means a person that causes or threatens to cause a discharge.

SECTION 2.15 – DWELLING UNIT

“Dwelling unit” means a structure or a portion of a structure that has independent living facilities including provisions for non-transient sleeping, cooking and sanitation.

SECTION 2.16 – EPA

“EPA” means the United States Environmental Protection Agency or any successor agency.

SECTION 2.17 – EXPRESS PLAN REVIEW SHEET

“Express plan review sheet” means a sheet promulgated by the County Engineer for the use of expeditiously reviewing construction drawings.

SECTION 2.18 – HARRIS COUNTY POLLUTION CONTROL

“Harris County Pollution Control” means a division within the Harris County Public Health and Environmental Services Department charged with investigating, monitoring, and reporting the release of pollutants within Harris County, and enforcing environmental regulations.

SECTION 2.19 – HEARING EXAMINER

“Hearing Examiner” means the person appointed by Commissioners Court to hold hearings concerning the appeal of a revocation, suspension, or denial of a SWQ Permit, a challenge to Harris County’s determination that a facility is a Type 1 or Type 2 facility, or that a discharge is contributing a substantial pollutant loading to the MS4.

SECTION 2.20 – IMPERVIOUS SURFACE

“Impervious surface” means any area that does not readily absorb water including, but not limited to, building roofs, parking and driveway areas, compacted or rolled areas that are not revegetated, sidewalks, and paved recreation areas.

SECTION 2.21 – INDUSTRIAL ACTIVITY CERTIFICATION

“Industrial Activity Certification” means a certificate approved by the County Engineer that covers storm water discharges from new development and significant redevelopment at a facility that either has, or will have, permit coverage for Storm Water Discharges Associated with Industrial Activity under a permit issued by the EPA or the TCEQ.

SECTION 2.22 – INDUSTRIAL MANAGER

“Industrial Manager” means the person designated by the County Engineer to oversee the Harris County program dealing with Storm Water Discharges Associated with Industrial Activity.

SECTION 2.23 – MULTI-FAMILY RESIDENTIAL

“Multi-family residential” means the use of property with one or more buildings on a parcel designed for and containing an aggregate of three or more dwelling units. Multi-family residential includes apartments, condominiums, boardinghouses, triplexes and quadriplexes.

SECTION 2.24 – MUNICIPAL SEPARATE STORM SEWER SYSTEM (MS4)

“Municipal separate storm sewer system” or “MS4” means the system of man-made conveyances owned or operated by a municipality, Harris County, or Harris County Flood

Control District, and designed or used for collecting or conveying storm water and which is not used for collecting or conveying sewage.

SECTION 2.25 – NEW DEVELOPMENT

“New development” means development of an undeveloped parcel of land five (5) acres or larger without regard to the amount of land that will actually be disturbed, except for:

(1) development on an existing undeveloped and undivided parcel of five acres or more of one single-family dwelling unit and one or more accessory structures; however, if the use of the property excluded under the foregoing exception at any time changes to a commercial use, including further subdividing of the property, the owner of the property shall comply with all applicable requirements of these Regulations;

(2) development of a single-family residential subdivision if:

(a) each lot in the subdivision will have no more than 20% impervious cover;

(b) no on-site detention for water quantity purposes is required by Harris County or the Harris County Flood Control District; and

(c) each lot in the subdivision will front on and will take direct access from an existing public road.

(3) projects constructed within waters of the United States and not associated with subdivisions, roads, or other commercial development.

(4) development that results in no impervious surface on the land disturbed.

SECTION 2.26 – NON-STRUCTURAL CONTROLS

“Non-structural controls” means a maintenance or operational practice designed to prevent or reduce the potential of storm water runoff contact with pollution-causing activities.

SECTION 2.27 – NOTICE OF CHANGE (NOC)

“Notice of change” or “NOC” means a written submission that is required by the TCEQ or EPA from a permittee authorized under a general permit who has submitted a Notice of Intent on which information must be corrected or changed.

SECTION 2.28 – NOTICE OF INTENT (NOI)

“Notice of intent” or “NOI” means a notice of intent form that is required by the TCEQ or EPA from an applicant requesting coverage under the terms of a general permit.

SECTION 2.29 – NOTICE OF TERMINATION (NOT)

“Notice of termination” or “NOT” means a notice of termination form that is required by the TCEQ or EPA from a permittee authorized under a general permit who is requesting termination of coverage under the permit.

SECTION 2.30 – NPDES

“NPDES” means the National Pollutant Discharge Elimination System.

SECTION 2.31 – NPDES PERMIT

“NPDES permit” means a permit issued by the EPA (or by the state under authority assumed pursuant to Section 1342(b) of Title 33 of the United States Code) that authorizes the discharge of pollutants to waters of the United States, whether the permit is applicable on an individual, group, or general basis.

SECTION 2.32 – ONE-STOP SHOP

“One-stop shop” means the Harris County Public Infrastructure Department – Permit Office that is responsible for Storm Water Quality Permit approval.

SECTION 2.33 – PARCEL

“Parcel” means a lot or contiguous piece of land that is under common ownership or control or that is part of a larger common plan of development or sale.

SECTION 2.34 – PERMITTEE

“Permittee” means the holder of the SWQ Permit.

SECTION 2.35 – PERSON

“Person” means an individual, corporation, organization, governmental entity, business trust, partnership, association, an agent or employee thereof, or any other legal entity.

SECTION 2.36 – POLLUTANT(S)

“Pollutant(s)” means dredged soil, solid waste, incinerator residue, sewage, garbage, sewage sludge, filter backwash, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt, and industrial, municipal and agricultural waste discharged into the MS4 or any waters in the state, or waters of the United States.

SECTION 2.37 – POLLUTION

“Pollution” means the alteration of the physical, thermal, chemical, or biological quality of, or the contamination of, any water in the state that renders the water harmful, detrimental, or injurious to humans, animal life, vegetation, or property or to public health, safety, or welfare, or impairs the usefulness or the public enjoyment of the water for any lawful or reasonable purpose.

SECTION 2.38 – PROPERTY OWNERS’ ASSOCIATION

“Property owners’ association” means an association composed of owners of the property pursuant to Texas Property Code Chapters 202 through 205, as amended. The property owners’ associations shall be one option in the ownership and maintenance of Storm Water Quality Features.

SECTION 2.39 – REPRESENTATIVE STORM EVENT

“Representative storm event” shall mean a storm event that is greater than one tenth (0.1) of an inch in magnitude and that occurs at least seventy-two (72) hours from the previously measurable (greater than one tenth (0.1) of an inch rainfall) storm event.

SECTION 2.40 – SEWAGE

“Sewage” means waste that is primarily organic and biodegradable or decomposable, and generally originates as human, animal, or plant waste from certain activities, including the use of toilet facilities, washing, bathing, and preparing food.

SECTION 2.41 – SIGNIFICANT REDEVELOPMENT

“Significant redevelopment” means an increase in the total amount of impervious surface on a previously developed five-acre or larger parcel so that the total resulting impervious surface is one acre or larger. Only additions of impervious surface after October 1, 2001 shall be totaled and counted toward the one-acre threshold.

SECTION 2.42 – SINGLE-FAMILY RESIDENTIAL

“Single-family residential” means the use of a lot with one building designed for and containing not more than two dwelling units.

SECTION 2.43 – STORM WATER DISCHARGES ASSOCIATED WITH CONSTRUCTION ACTIVITY

“Storm Water Discharges Associated with Construction Activity” means any storm water discharges from construction activity including, clearing, grading, excavation, and demolition activities, except operations that result in the disturbance of less than five acres of total land area that are not part of a larger common plan of development or sale. The term does not include discharges from facilities or activities excluded from the NPDES program under Part 122 of Title 40 of the Code of Federal Regulations.

SECTION 2.44 – STORM WATER DISCHARGES ASSOCIATED WITH INDUSTRIAL ACTIVITY

“Storm Water Discharges Associated with Industrial Activity” means the same as defined in Section 122.26 (b)(14) of Title 40 of the Code of Federal Regulations, except that it shall not include discharges from the activities enumerated in subsection (x) of that section.

SECTION 2.45 – STORM WATER POLLUTION PREVENTION PLAN (SWPPP)

“Storm water pollution prevention plan” or “SWPPP” means a plan prepared and required for the purpose of complying with federal, state, or Harris County regulations governing Storm Water Discharges Associated with Construction Activity or Industrial Activity.

SECTION 2.46 – STORM WATER QUALITY ENGINEER

“Storm Water Quality Engineer” means the person designated by the County Engineer to approve Storm Water Quality Management Plans.

SECTION 2.47 – STORM WATER QUALITY FEATURES

“Storm water quality features” means the devices or structures created using Best Management Practices to eliminate or reduce pollution discharged into the MS4.

SECTION 2.48 – STORM WATER QUALITY MANAGEMENT PLAN (SWQMP)

“Storm water quality management plan” or “SWQMP” means a plan prepared by an engineer licensed in the State of Texas in accordance with Part B, Section 2 of these Regulations.

SECTION 2.49 – STORM WATER QUALITY PERMIT (SWQ Permit)

“Storm Water Quality Permit” or “SWQ Permit” means the permit issued by the County Engineer indicating that the operator of a site or facility has submitted and obtained approval of the necessary plans, and given the proper notices, as required by these Regulations.

SECTION 2.50 – STRUCTURAL CONTROL

“Structural control” means a structure or vegetative practice that is generally designed to reduce pollutant levels in storm water runoff.

SECTION 2.51 – TCEQ

“TCEQ” means the Texas Commission on Environmental Quality and any successor agency.

SECTION 2.52 – TPDES

“TPDES” means the Texas Pollutant Discharge Elimination System that was assumed by the state from the EPA pursuant to Section 1342(b) of Title 33 of the United States Code.

SECTION 2.53 – TPDES PERMIT

“TPDES permit” means a permit issued by the TCEQ that authorizes the discharge of pollutants to water in the state, whether the permit is applicable on an individual, group, or general basis.

SECTION 2.54 – TYPE 1 FACILITY

“Type 1 facility” means a municipal landfill, hazardous waste treatment disposal and recovery facility, a facility that is subject to Section 11023 of Title 42 of the United States Code (toxic release inventory program), as it may be amended from time to time, and any other industrial facility that Harris County determines is contributing a substantial pollutant loading to the MS4.

SECTION 2.55 – TYPE 2 FACILITY

“Type 2 facility” means any facility excluding a Type 1 facility, which may include any other municipal waste treatment, storage or disposal facilities (including, but not limited to, publicly owned treatment works, transfer stations, and incinerators) and any other individual industrial or commercial facility, or category of facilities engaging in a particular commercial or industrial activity, Harris County believes is contributing a substantial pollutant loading to the MS4.

SECTION 2.56 – UNINCORPORATED AREA

“Unincorporated area” means the area in Harris County, Texas, which is not within an incorporated area of a city, town or village.

SECTION 2.57 – WATERS OF THE UNITED STATES

“Waters of the United States” means all waters which are currently used, were used in the past, or may be susceptible to use in interstate or foreign commerce; all interstate waters, including interstate wetlands; all other waters the use, degradation or destruction of which would affect or

could affect interstate or foreign commerce; all impoundments of waters otherwise defined as waters of the United States under this definition; all tributaries of water identified in this definition; all wetlands adjacent to the waters identified in this definition; and any other waters within the federal definition of “waters of the United States” in Section 122.2 of Title 40 of the Code of Federal Regulations; but not including any waste treatment systems, treatment ponds, or lagoons designed to meet the requirements of the federal Clean Water Act.

SECTION 2.58 – WETLANDS

“Wetlands” means an area that is inundated or saturated by surface or ground water at a frequency and duration sufficient to support and that under normal circumstances does support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamp, marshes, bogs, and similar areas.

PART B – POST-CONSTRUCTION CONTROLS ON NEW DEVELOPMENT AND SIGNIFICANT REDEVELOPMENT

Section 1 – Storm Water Quality Permit Process

SECTION 1.01 – ADMINISTRATION BY COUNTY ENGINEER

The County Engineer or his designee is responsible for the administration of these Regulations dealing with post-construction controls on new development and significant redevelopment, the issuance of Storm Water Quality Permits required by these Regulations, the enforcement of these Regulations and maintaining proper records.

SECTION 1.02 – PERMITS REQUIRED

All new development and significant redevelopment within the unincorporated areas of Harris County, Texas without first securing a SWQ Permit, or submitting an Industrial Activity Certification in accordance with Part B, Section 1.05 is prohibited.

If any portion of a project drains directly into a Municipal Separate Storm Sewer System owned by Harris County or the Harris County Flood Control District, that project must have a SWQ Permit issued by Harris County. The granting of a SWQ Permit does not imply that federal or state storm water management criteria have been met and is in addition to any other development permit required in Harris County.

SECTION 1.03 – DURATION

The SWQ Permit shall expire one year from the date the Storm Water Quality Features, created pursuant to a Storm Water Quality Management Plan, receive final approval for operation, but may be renewed. Final approval for operation occurs upon the issuance of a Certificate of Compliance by the County Engineer pursuant to Part B, Section 4.02.

SECTION 1.04 – APPLICABILITY

Except as provided in Part B, Section 1.02, the requirements to obtain a SWQ Permit shall not apply to new development involving any of the following:

- (a) Any project that has, prior to October 1, 2001, received a completed and unexpired application for a preliminary or final subdivision plat on file with a municipality provided the project is substantially underway by October 1, 2003;
- (b) Any project that has an initial construction plan review from Harris County by October 1, 2001, or in the case of a project not receiving an initial construction plan review, has submitted a valid development permit application to Harris County by October 1, 2001, provided the project is substantially underway by October 1, 2003;
- (c) For toll road projects, if there is a preliminary or approved master drainage plan associated with the project prior to October 1, 2001; or
- (d) For Harris County or Harris County Flood Control District channel, basin, roadway, or bridge projects, if the date of authorization or notice to proceed with the preliminary engineering report from Harris County or the Harris County Flood Control District to the consultant is prior to October 1, 2001; or

- (e) linear projects such as underground pipelines, utilities, or drainage where the resulting impervious surface is limited to less than one acre. For this exemption, plans and drawings showing the total resultant impervious surface must be submitted to the County Engineer. Any future extensions or changes to the impervious surface shall be counted toward the one-acre threshold.

SECTION 1.05 – INDUSTRIAL ACTIVITY CERTIFICATION

If new development or significant redevelopment occurs at a facility that either has or will have permit coverage for Storm Water Discharges Associated with Industrial Activity issued by the TCEQ, the operator shall submit an Industrial Activity Certification on a form prescribed and approved by the County Engineer to the Storm Water Quality Engineer. An Industrial Activity Certification shall also include any of the following:

- (a) A copy of the application for an individual permit from the TCEQ or EPA for Storm Water Discharges Associated with Industrial Activity at the facility;
- (b) A copy of the permit issued by the TCEQ or EPA for Storm Water Discharges Associated with Industrial Activity at the facility;
- (c) A copy of the NOI for coverage under a general permit for Storm Water Discharges Associated with Industrial Activity issued by the TCEQ, or the no-exposure certification referenced in Part D, Section 2.02;
- (d) A statement of commitment to file an application for an individual permit from the TCEQ for Storm Water Discharges Associated with Industrial Activity at the facility; or
- (e) A statement of commitment to file a NOI for coverage under a general permit for Storm Water Discharges Associated with Industrial Activity issued by the TCEQ.

SECTION 1.06 – APPLICATION

The application for a Storm Water Quality Permit shall be on a form prescribed and approved by the County Engineer and shall be supported by the following:

- (a) A complete set of construction plans including a Storm Water Quality Management Plan which must be approved by the Storm Water Quality Engineer under Part B, Section 2 of these Regulations;

- (b) A fee in the amount of \$300.00 paid in cash, cashiers check, personal check, or money order. Checks shall be made out to “Harris County Treasurer”;
- (c) If a bond is required by the Regulations of Harris County, Texas for the Approval and Acceptance of Infrastructure, the amount of the bond shall be increased by an amount equal to the cost of constructing the Storm Water Quality Features. A copy of the bond shall be submitted with the application;
- (d) A copy of the NOI to discharge Storm Water Associated with Construction Activity submitted or to be submitted to the EPA or TCEQ; and
- (e) One of the following to demonstrate proof or ownership and maintenance responsibility where appropriate:
 - 1. a copy of a letter from a municipal utility district, a public utility district, a water control and improvement district, a fresh water supply district, or any other utility or water district created pursuant to state law;
 - 2. a copy of creation documents from a Property Owners’ Association; or
 - 3. documents from individual owners.
- (f) An Affidavit to the Public in a form and containing the statements prescribed by the County Engineer that has been recorded in accordance with Part B, Section 4.03.

The County Engineer may require the submission of additional information, drawings, specifications or documents to determine whether a SWQ Permit shall be issued from the information submitted.

SECTION 1.07 – DETERMINATION OF PERMIT ELIGIBILITY

After the application is filed, the County Engineer shall:

- (a) Issue the SWQ Permit if he is satisfied that that applicant has met all the requirements of Part B, Section 1.06; or
- (b) Return the application and supporting data to the applicant if any provision of these Regulations is not met. The County Engineer shall notify the applicant in writing of items required for further review of the plans.

SECTION 1.08 – PERMIT RENEWAL

Storm Water Quality Permits shall be renewed annually. The date of renewal shall be the anniversary date the Storm Water Quality Features received final approval for operation pursuant to Part B, Section 4.02. Failure to renew the SWQ Permit before this date means it expires and the person must reapply for a SWQ Permit as required by Part B, Section 1.06 above.

To renew a SWQ Permit the following items must be submitted:

- (a) A permit renewal form as prescribed and approved by the County Engineer;
- (b) A Certificate of Proper Operation completed by the owner or owner's agent;
- (c) On all projects that involve any structural controls, a certification completed by a professional engineer licensed in the State of Texas that all such controls conform to the plans and technical specifications in the SWQMP; and
- (d) A renewal fee in the amount of \$150.00, together with any outstanding inspection or other fees, paid in cash, cashiers check, personal check, or money order. Checks shall be made payable to the "Harris County Treasurer."

All outstanding inspection or other fees owed Harris County shall be paid prior to renewal of the SWQ Permit. Harris County shall not renew a SWQ Permit if such fees are outstanding.

SECTION 1.09 – TERM OF PERMITS

Development activity under the SWQ Permit must start within 180 days from the date of issuance. Failure to initiate development activity shall result in the SWQ Permit becoming invalid. Upon written request, the County Engineer may grant two (2) six-month extensions.

Section 2 – Storm Water Quality Management Plans

SECTION 2.01 – PLAN APPROVAL REQUIRED

Before the County Engineer shall approve a SWQ Permit, a Storm Water Quality Management Plan must be approved by the Storm Water Quality Engineer.

SECTION 2.02 – PLAN APPROVAL PROCESS

The Storm Water Quality Management Plan shall be submitted as follows:

- (a) The SWQMP shall be prepared in accordance with the Storm Water Management Handbook for Construction Activities and the Storm Water Quality Management Guidance Manual or the Storm Water Quality Guidance Document for New Development/Redevelopment Projects. If applicable to the BMP selected, the SWQMP shall incorporate features from the Minimum Design Criteria for Implementation of Certain Best Management Practices for Storm Water Runoff Treatment Options as set forth in Appendix A. Alternate techniques and methods not mentioned in the Storm Water Quality Management Guidance Manual, Storm Water Quality Guidance Document for New Development/Redevelopment Projects, Storm Water Management Handbook for Construction Activities, or the Minimum Design Criteria for Implementation of Certain Best Management Practices for Storm Water Runoff Treatment Options shall be reviewed on a case-by-case basis.
- (b) A preliminary set of drawings shall be submitted to the “One-Stop Shop” for initial review. If a site has Storm Water Discharges Associated with Construction Activity then a preliminary set of drawings and a SWPPP shall be submitted. The Express Plan Review Sheet shall be a portion of this submittal. The review will be conducted in conjunction with the review for compliance with the Regulations of Harris County, Texas, for Flood Plain Management; Regulations of Harris County, Texas, for Driveways and Culverts; and the Harris County Flood Control Criteria Manual. Construction control measures including applicable standard drawings shall be included in the submittal. Once reviewed, the drawings shall be returned to the applicant with comments.
- (c) Any preliminary drawings or plans altered or marked by the Storm Water Quality Engineer shall be resubmitted along with the corrected original drawings for signature. If further corrections are required, the package shall be returned to the applicant for resubmittal upon completion of revisions.
- (d) Drawings shall meet the same standards as far as size, line weight, etc., as outlined in the Rules, Regulations and Requirements Relating to the Approval and Acceptance of Improvements in Subdivisions or Resubdivisions and/or the Harris County Flood Control Criteria Manual.

- (e) Acceptable Low Impact Development (LID) applications may be proposed as an alternative to applicable sections of these regulations. All proposals must meet and follow the Harris County Low Impact Development & Green Infrastructure Design Criteria for Storm Water Management, Appendix C, as adopted by Commissioners Court.

SECTION 2.03 – PLAN AMENDMENT PROCESS

The Storm Water Quality Management Plan may be amended by resubmitting the plan with the requested changes to the “One Stop Shop” for review in accordance with the procedures for initial plan approval set forth in Part B, Section 2.02. If the plan change involves an amendment to the design of any previously approved structural control, a fee shall be charged in accordance with Part B, Section 8.01 for review and processing of the amendment and issuance of an amended permit.

Section 3 – Ownership and Maintenance of the Storm Water Quality Features

SECTION 3.01 – OWNERSHIP AND MAINTENANCE

Ownership and maintenance of the Storm Water Quality Features designed and built pursuant to Part B, Section 2.02 of these Regulations shall be according to the following:

- (a) The Storm Water Quality Feature shall remain with the owner unless there is a transfer pursuant to Part B, Section 4.04.
- (b) If Harris County or the Harris County Flood Control District accepts the Storm Water Quality Features for maintenance, the permit holder’s requirements for the SWQ Permit and permit renewal with respect to that feature as set forth in Part B, Sections 1.02 and 1.08 terminate. All other permit requirements continue to apply.

Section 4 – Permittee Responsibilities

SECTION 4.01 – RESPONSIBILITIES OF ALL PERMITTEES

All permittees shall:

- (a) Comply with the SWQMP;
- (b) Remove all soil deposits resulting from runoff or from vehicular construction traffic and/or from site operations from the road adjacent roadside ditch on a daily or more frequent basis, or as specified in the Storm Water Quality Management Plan;
- (c) Post the SWQ Permit on the job site in a place visible from the nearest road or street during the construction phase; and
- (d) Allow the County Engineer to inspect the work pursuant to a permit. The County Engineer may make as many scheduled or unscheduled inspections as he may deem necessary to enforce these Regulations and shall have access to any building or premise at any reasonable time. If no specific inspection standards are set by any part of these Regulations, the inspection shall only be to determine that the drawings and specifications furnished with the SWQ Permit application are met.

SECTION 4.02 – CERTIFICATIONS AND INSPECTIONS

All Storm Water Quality Features shall be constructed in accordance with the plans approved by the County Engineer. Permittees shall inspect and certify that its Storm Water Quality Features are constructed and operated according to submitted plans as follows:

- (a) When the Storm Water Quality Features are complete and ready for use, a professional engineer licensed in the state of Texas must inspect and certify that the Storm Water Quality Features were completed in accordance with the approved plans. The permittee shall then submit an As-Built Certification form supplied by the County Engineer. The form must be completed, signed, and sealed by a professional engineer licensed in the State of Texas indicating that the Storm Water Quality Features were completed in accordance with the approved plans.

- (b) Once the As-Built Certification and any certification authorized by the SWQMP are submitted to the County Engineer's office, the County Engineer will issue or deny a Certificate of Compliance. Should the County Engineer determine that the applicable certifications were not provided, or the provisions of Part B, Section 1.06 of these regulations were not followed, then enforcement procedures such as SWQ Permit revocation or civil enforcement may commence. The County Engineer may deny a Certificate of Compliance if he determines that the Storm Water Quality Features were not constructed in accordance with approved plans.
- (c) Should the County Engineer have to make additional inspections or conduct survey work due to non-compliance with these Regulations, additional fees may be assessed as outlined in Part B, Section 8.

SECTION 4.03 – RECORDATION

Recordation of the obligation to comply with the Storm Water Quality Permit requirements shall be in the form of an Affidavit to the Public as prescribed by the County Engineer according to the following:

- (a) The obligation to comply with the SWQ Permit requirements shall be recorded by the permittee in the Real Property Records of Harris County, Texas for the affected parcel and will apply to all subsequent owners of all or a portion of the parcel. The recordation shall note that no structural or non-structural controls on, or for the parcel, may be changed from the plans and technical specifications in the SWQ Permit for the parcel. If there are substantial changes in the structural or non-structural controls then the procedures as outlined in Part B, Section 1.06 shall be followed. For Storm Water Quality Features that are not accepted by the Harris County Flood Control District for maintenance, the recordation shall reflect that the features are private and must be properly maintained by the owner in accordance with the SWQMP.
- (b) For new development that includes the platting of a reserve tract, a notation shall be placed on the subdivision plat that a SWQ Permit must be obtained before the

issuance of any development permit for a structure on all or a part of the reserve tract.

- (c) Third-party permittees: For subdivisions involving the Property Owners' Association, the agreement shall be recorded for all parcels in the subdivision. For other new development or significant redevelopment for which there is a third-party permittee, the third-party agreement shall be recorded for all parcels subject to the rights and obligations specified in the agreement at the time of the transfer of the SWQ Permit to the third-party permittee.
- (d) The applicant, or if the SWQ Permit has already been issued, the permittee, shall pay all recording fees required by the county clerk's office.

SECTION 4.04 – TRANSFER

A permittee may transfer its Storm Water Quality Permit in accordance with the following:

- (a) The SWQ Permit may be held by an entity or person other than the landowner if the entity or person and the landowner enter into a binding legal agreement that meets the requirements of this section. The entity or person must agree to comply with the requirements of these Regulations and with the terms and conditions of the SWQ Permit, including adherence to the operation and maintenance requirements specified in Part B, Section 3.
- (b) The third-party agreement shall grant fee simple title to all structural controls to the entity or person, provide an easement if necessary to allow access by the entity or person across the landowner's property to maintain structural controls or to implement non-structural controls, and if necessary, to allow storm water from the landowner's property to drain across any adjacent property to a designated structural control. The legal agreement shall also provide that in the event of its termination for any reason, including either by choice or by default, the obligation to comply with the provisions of this section shall revert to the landowner.

Section 5 – Suspension and Revocation of Storm Water Quality Permits

SECTION 5.01 – SUSPENSION OF PERMITS

SWQ Permit suspensions are handled in accordance with the following provisions:

- (a) A SWQ Permit is suspended when the County Engineer, or his inspector, advises the permittee or some responsible person on the job that the SWQ Permit is suspended and posts a written suspension notice over the SWQ Permit at the jobsite.
- (b) The following actions by the permittee are grounds for suspension of a SWQ Permit:
 - 1. Non-compliance with Part B, Sections 2 or 4 of these Regulations;
 - 2. Deviating from drawings and specifications filed with the County Engineer and refusing to make corrections required by the County Engineer; or
 - 3. Any grounds for revocation of a SWQ Permit as outlined in Part B, Section 5.02.
- (c) When the suspension notice is posted, the permittee must immediately suspend all work on the job except that work necessary to abate the suspension. The suspension will be abated when the corrective work is performed and has passed inspection. The abatement will be evidenced by the removal of the suspension notice by the County Engineer or his inspector and the notation on the Permit Notice by the County Engineer or his inspector that the work has now been re-inspected and passed. The suspension notice may not be removed by any person other than the County Engineer or his inspector and removal by any other person will be ineffective.

SECTION 5.02 – PERMIT REVOCATION

A Storm Water Quality Permit shall be revoked after notice and opportunity for a hearing pursuant to Part B, Section 5.03 of these regulations if any of the following occur:

- (a) Material deviation from the drawings and specifications on file with the County Engineer, including the SWPPP, or a pattern of consistent deviation from such

drawings and specifications which would demonstrate an intention to avoid conformity with the requirements of the SWQ Permit;

- (b) Refusal to uncover work for a mandatory inspection;
- (c) Removal of a permit suspension notice;
- (d) Proceeding with work while a permit is suspended, other than such work necessary to abate a suspension;
- (e) An act or acts of violence, or threat or threats of violence, against the County Engineer or his inspector either on or off the job for the purpose of intimidating the County Engineer or his inspector, so that he will not perform his inspection duties;
- (f) Falsifying information in the SWQ Permit application; or
- (g) Failing to submit all required certifications as outlined in Part B, Section 4.02.
- (h) Consistent violation of the NPDES or TPDES permit for the project during construction, including failure to correct deficiencies noted during construction-phase inspections.

SECTION 5.03 – PERMIT REVOCATION PROCEDURES

Storm Water Quality Permits shall be revoked in the following manner:

- (a) The County Engineer shall file a complaint stating the reason for SWQ Permit revocation with the Hearing Examiner.
 - 1. The Examiner will set a hearing as soon as practicable, but within thirty (30) days.
 - 2. The Examiner will deliver the original Complaint and Hearing Notice to the Clerk of Commissioners Court to be filed, give one copy to the County Engineer, and designate an appropriate person as Serving Agent and give two copies to him or her.
 - 3. The Serving Agent will take the two copies of the Complaint and Hearing Notice to the site where he will:
 - a. Hand one copy of the Complaint and Hearing Notice to the permittee, or

- b. If the permittee is not an individual or cannot be found on the site, the Serving Agent will hand one copy of the Complaint and Hearing Notice to the person on the site who appears to be in charge, or
 - c. If no person can be found on the site, the Serving Agent will post the Complaint and Hearing Notice over the SWQ Permit and/or Notice of Suspension posted at the job. Upon posting of the Complaint and Hearing Notice the SWQ Permit shall be suspended.
4. The Serving Agent will fill in the return on the remaining copy, noting on it the date, time and manner in which he perfected service, and sign the return and return the remaining copy to the Hearing Examiner.
5. At the time set for hearing, if the return copy of the Complaint has been returned to the Hearing Examiner by the serving agent, and reflects that service has been perfected, the Examiner may proceed with the hearing.
6. Hearings will be conducted in the manner provided for by Part B, Section 6.02 of these Regulations before the Hearing Examiner appointed by Commissioners Court and the Examiner may delegate responsibilities of Hearing Examiner to his Assistant. The Examiner's decision and review by Commissioners Court are governed by Part B, Sections 6.03 and 6.04.

Section 6 – Appeals and Hearing Procedures, Variances, and Review by Commissioners Court

SECTION 6.01 – APPEALS

If a permit applicant is denied a SWQ Permit or has his SWQ Permit suspended he may appeal the denial or suspension as provided in this Section. The term “appellant” is used to refer to the appealing party. An appellant must seek his remedy under this procedure before seeking his remedy in court. Application for a permit is deemed to be a waiver of the right to challenge these Regulations before exhausting remedies herein provided. The appeals process is as follows:

- (a) Appeals are initiated by the making of complaint with or by requesting an exception to the Regulations from the Hearing Examiner in writing.
- (b) The Hearing Examiner will set a time for a hearing, which will be scheduled as soon as practicable but within thirty (30) days of the receipt of the written complaint or

request, and shall prepare a Notice of Public Hearing naming the time and date of the Hearing. Copies shall be distributed as follows:

1. The original copy and the Certificate to Commissioners Court will be filed with the Clerk of Commissioners Court and the Clerk will prepare a file for the Hearing Notice.
 2. The Examiner will set up his own working or hearing file, in which he will keep one copy.
 3. The Examiner will give one copy to the Appellant.
 4. The Examiner will deliver one copy to the County Engineer. The Hearing will be conducted as provided in Part B, Section 6.02.
- (c) Appeal of a suspension will not abate the suspension pending the decision of the Hearing Examiner.

SECTION 6.02 – HEARING BEFORE THE EXAMINER

At Hearings before the Examiner, the Examiner will hear the testimony of the County Engineer and any witnesses called by the County Engineer. The Examiner will hear the testimony of the appellant and any witnesses called by the appellant. The Examiner will review all documents and exhibits submitted to him by the parties. The Examiner will not be bound by formal rules of evidence and will control the evidence, reserving to himself the power to exclude testimony or exhibits he does not consider relevant. The Hearing Examiner will maintain an accurate record of the evidence adduced at the Hearing.

SECTION 6.03 – FILING OF EXAMINER'S DECISION

The Examiner will prepare a written decision within three (3) working days of the Hearing. A copy of his decision will be filed with the Clerk of Commissioners Court, the members of the Commissioners Court, and with the County Engineer. The original will be sent to the appellant's address shown on the SWQ Permit or application. If a variance is granted, the County Engineer shall prepare the appropriate permit with any special requirements that may be required by the conditions of the variance.

SECTION 6.04 – REVIEW BY COMMISSIONERS COURT

If the County Engineer or the appellant wishes to appeal the Examiner's decision, a written objection must be filed with the Clerk of Commissioners Court within ten (10) days from the date the Examiner's decision is filed. The Clerk will notify the Hearing Examiner who will place the matter on the Agenda of Commissioners Court for review at the next meeting of Commissioners Court. If the County Engineer files the objection, notice that the matter is on the agenda will be sent to the appellant by mail at the appellant's address shown on the SWQ Permit or application. Commissioners Court will review the matter. The Commissioners Court may either affirm or reverse the decision of the Hearing Examiner. A suspension of a permit upheld by the Hearing Examiner will not be abated pending the review of Commissioners Court.

SECTION 6.05 – VARIANCES

If any person wishes an exception to any provision of these Regulations, he or she shall request a variance in the manner prescribed for the filing of an appeal by Part B, Section 6.01 with the Hearing Examiner. The Hearing Examiner shall hold a hearing, and deny or grant the variance. Variances will be granted only if the conditions below are met:

- (a) The applicant has shown good and sufficient cause;
- (b) It has been determined that failure to grant the variance would result in an exceptional hardship to the applicant; and
- (c) The granting of a variance will not result in a pollutant discharge, additional threats to public safety, extraordinary public expense, or create nuisances, cause fraud or victimization of the public.

Economic hardship shall not constitute the sole basis for granting a variance. A hearing before Commissioners Court regarding variances shall be requested in the manner provided in Part B, Section 6.04 of these Regulations. If a variance is granted a SWQ Permit shall be issued and the permittee shall conform to all applicable provisions of these Regulations except the section or sections for which a variance is granted.

Section 7 – Forms and Records

SECTION 7.01 – FORMS AND RECORDS

Forms to be used in the administration of these Regulations shall be provided and approved by the County Engineer. All forms shall be available at the Harris County Public Infrastructure Department and may be amended or supplanted from time to time by the County Engineer.

Section 8 – Fees

SECTION 8.01 – FEES

Fees for SWQ Permits and inspections are to be set by Commissioners Court. Fees shall be paid by cash, cashiers check, money order, or personal check. Should the check be returned for insufficient funds the SWQ Permit issued becomes invalid. Fees shall be paid at the time the SWQ Permit is delivered to the permittee unless the County Auditor has approved other arrangements. The following fee schedule applies to actions under these Regulations:

INITIAL PERMIT	\$300.00
YEARLY PERMIT RENEWAL FEE	\$150.00
INSPECTION/REINSPECTION FEE	\$ 50.00
CERTIFICATE OF COMPLIANCE	\$ 20.00
CERTIFICATE OF NON-COMPLIANCE	\$100.00
PLAN/PERMIT AMENDMENT – STRUCTURAL CONTROL	\$150.00
TRANSFER OF PERMIT	\$300.00

Section 9 – Civil Enforcement

SECTION 9.01 – CIVIL ENFORCEMENT

If any person violates any section dealing with Post-Construction Controls on New Development and Significant Redevelopment, the County Attorney may take whatever action is necessary to remedy the violation, including but not limited to filing suit for civil penalties up to \$1,000 a day for each violation, and to enjoin the violation. Each day a violation continues is considered a separate violation for purposes of assessing the civil penalty. Nothing in these Regulations precludes Harris

County through the County Attorney's Office from seeking enforcement of state environmental laws pursuant to the Texas Water Code.

SECTION 9.02 – CERTIFICATE OF NON-COMPLIANCE

If the County Engineer determines that a development site or sites does not comply with these Regulations, he may issue a Certificate of Non-Compliance and file the same in the Real Property Records of Harris County, Texas.

PART C – STORM WATER DISCHARGES ASSOCIATED WITH CONSTRUCTION ACTIVITY

Section 1 – In General

SECTION 1.01 – ADMINISTRATION BY COUNTY ENGINEER

The County Engineer or his designee is responsible for the administration of these Regulations dealing with the Storm Water Discharges Associated with Construction Activity, and the issuance of SWQ Permits required by these Regulations, and enforcement of these Regulations and maintaining proper records.

SECTION 1.02 – COMPLIANCE WITH PERMIT AND SWPPP

The owner and operator of a facility that is required to have a NPDES or TPDES permit to discharge storm water associated with construction activity shall prepare its SWPPP in accordance with Harris County's Storm Water Management Handbook for Construction Activities and shall strictly comply with the requirements of its NPDES or TPDES permit, the SWQ Permit issued under these Regulations and its SWPPP. It is a violation of these Regulations to operate a facility that has Storm Water Discharges Associated with Construction Activity without an NPDES or TPDES permit for stormwater discharges or in violation of the NPDES or TPDES permit, the SWQ Permit covering the facility, or the SWPPP.

SECTION 1.03 – SUBMISSION OF NOI

The operator of a facility required to have a NPDES or TPDES permit to discharge storm water associated with construction activity shall not commence construction activity without first submitting an NOI to the EPA or the TCEQ, as appropriate, and shall submit to the Storm Water Quality Engineer:

- (a) a copy of the NOI submitted to the EPA or the TCEQ;
- (b) a certification that the NOI has been submitted to the EPA or the TCEQ as applicable; and
- (c) a copy of a site plan detailing the location of erosion control measures.

The documents required by this section must be submitted to the Storm Water Quality Engineer at the same time the operator submits the NOI to the EPA or TCEQ as applicable.

SECTION 1.04 – SUBMISSION OF NOT

An operator who has filed an NOI with Harris County must submit a certification that he has submitted an NOT to the EPA or TCEQ and a copy of that NOT to the Storm Water Quality Engineer at the same time the operator submits the NOT to the EPA or the TCEQ as applicable.

Section 2 – Inspections

SECTION 2.01 – INSPECTION PROCEDURES

Harris County will make periodic unannounced inspections of the site during construction to insure compliance with the Storm Water Pollution Prevention Plan. Compliance with the provisions of the SWPPP will be checked on every visit, including the following items:

- (a) Proper public notice;
- (b) Copies of NOI, SWQ Permit, SWPPP, and SWQMP onsite;
- (c) Condition and effectiveness of erosion and sediment control devices;
- (d) Condition of entrance so as to reduce vehicle tracking;
- (e) Inspection and maintenance records;
- (f) Proper fueling and/or washout area construction;
- (g) Sanitary facilities; and

- (h) Proper storage and end of workday containment of trash, construction debris, and work materials.

A Notice of Inspection will be issued to the responsible party. If deficiencies are noted, they must be corrected within 72 hours of receiving a notice. Upon reinspection, if the deficiencies have not been corrected from the first inspection or additional deficiencies are identified, a \$50.00 reinspection fee will be assessed in accordance with the fee schedule set forth in Part B, Section 8 of these Regulations. This fee will be assessed on every reinspection conducted where the previous deficiencies were not addressed or new deficiencies are noted and is in addition to any civil penalty that may be imposed under Part C, Section 3.01 of these Regulations. An inspection by Harris County does not insure compliance with any federal or state storm water requirements.

Section 3 – Civil Enforcement

SECTION 3.01 – CIVIL ENFORCEMENT

If any person violates any section dealing with Storm Water Discharges Associated with Construction Activity, the County Attorney may take whatever action is necessary to remedy the violation, including but not limited to filing suit for civil penalties up to \$1,000 a day for each violation, and to enjoin the violation. Each day a violation continues is considered a separate violation for purposes of assessing the civil penalty. Nothing in these Regulations precludes Harris County through the County Attorney's Office from seeking enforcement of state environmental laws pursuant to the Texas Water Code.

SECTION 3.02 – CERTIFICATE OF NON-COMPLIANCE

If the County Engineer determines that a development site or sites does not comply with these Regulations, he may issue a Certificate of Non-Compliance and file the same in the Real Property Records of Harris County, Texas.

PART D – STORM WATER DISCHARGES ASSOCIATED WITH INDUSTRIAL ACTIVITY

Section 1 – In General

SECTION 1.01 – ADMINISTRATION

The Industrial Manager or his designees and Harris County Pollution Control are responsible for the administration of these Regulations dealing with the Storm Water Discharges Associated with Industrial Activity, the enforcement of these Regulations, and maintaining proper records.

SECTION 1.02 – UNPERMITTED DISCHARGES PROHIBITED

The owner or operator of a facility that has Storm Water Discharges Associated with Industrial Activity violates these Regulations if the owner or operator causes, suffers, allows, or permits a discharge into the MS4 without having first obtained authorization under an NPDES permit, TPDES permit, or is otherwise authorized by the TCEQ to discharge storm water. Any violation of any general or individual NPDES or TPDES permit is a violation of these Regulations.

SECTION 1.03 – SUBMISSION OF NOI

If the owner or the operator of a facility that has Storm Water Discharges Associated with Industrial Activity has coverage for those discharges under an NPDES or TPDES general storm water permit, the owner or operator shall submit to the Industrial Manager a copy of the NOI to obtain coverage for that facility. A copy of the NOI must be submitted to the Industrial Manager no later than fourteen (14) calendar days after filing the NOI with the EPA or TCEQ for such coverage.

SECTION 1.04 – SUBMISSION OF NOC

The owner or the operator of a facility that has Storm Water Discharges Associated with Industrial Activity and who is required by their NPDES or TPDES permit to submit an NOC to the EPA or TCEQ shall submit to the Industrial Manager a copy of the NOC.

SECTION 1.05 – SUBMISSION OF NOT

The owner or the operator of a facility that has Storm Water Discharges Associated with Industrial Activity and who is required by their NPDES or TPDES permit to submit an NOT to the EPA or TCEQ shall submit to the Industrial Manager a copy of their NOT.

If an NOT is submitted because the operator of the facility has changed, a copy of the NOI for the new operator shall be submitted to the Industrial Manager with the NOT.

The copy of the NOT shall be submitted no later than ten (10) calendar days after either all Storm Water Discharges Associated with Industrial Activity are eliminated at the facility or the operator of the facility changes.

SECTION 1.06 – DESIGNATION AS A TYPE 1 OR TYPE 2 FACILITY

Harris County may determine that an individual industrial or commercial facility, or a category of facilities engaging in a particular industrial or commercial activity, are contributing a substantial pollutant loading to the MS4 and are, therefore, Type 1 or Type 2 facilities. Designation as a Type 1 or Type 2 facility shall be based upon such factors as the nature of the activities at the facility and drainage patterns in the area.

Upon designation by Harris County as a Type 1 or Type 2 facility, the Industrial Manager shall send written notification by certified mail, return receipt requested, to any such facility informing the facility of the designation. The facility may then appeal the designation in the manner set forth in Part E, Section 2.01 of these Regulations.

Section 2 – Monitoring

SECTION 2.01 – MONITORING REQUIRED

Operators of facilities that have storm water discharges shall comply with the following monitoring requirements:

- (a) All Type 1 and Type 2 facilities required to have authorization to discharge storm water under an NPDES or TPDES permit must undertake all monitoring required by that permit. Upon request, the operator of the facility shall submit the results of this monitoring to the Industrial Manager. The monitoring methods employed by the operators must follow EPA standards for monitoring as set forth in 40 CFR Part 136 as amended, and 30 TAC 319, as amended.
- (b) If a Type 1 facility is not required to have authorization to discharge storm water under an NPDES or TPDES permit, the facility must on an annual basis analytically monitor storm water discharges from its facility during a representative storm event on an outfall-by-outfall basis for the following parameters:
1. Any pollutants limited in an existing NPDES or TPDES permit for the facility;
 2. Total oil and grease;
 3. Chemical oxygen demand;
 4. pH;
 5. Biochemical oxygen demand, five-day;
 6. Total suspended solids;
 7. Total phosphorous;
 8. Total Kjeldahl nitrogen;
 9. Nitrate plus nitrite nitrogen;
 10. Total organic carbon;
 11. Ammonia (as N);
 12. Temperature;
 13. Any pollutants for which effluent limitations are imposed in the County's storm water permit for its MS4; and
 14. Any other pollutant that Harris County has determined the facility is discharging which contributes a substantial pollutant loading to the MS4 after written notification by the County sent by certified mail, return receipt requested, informing the facility that the pollutant must be analyzed.

All sampling conducted by a facility shall occur during a representative storm event and shall be completed within the first 30 minutes of discharge using a grab sample. If it is not practicable to complete the sampling within the first 30 minutes, sampling must be

completed within the first hour of discharge. For facilities monitoring under this subsection, Harris County has established thresholds which are set forth in Appendix B.

- (c) If a Type 2 facility is not required to have authorization to discharge storm water under an NPDES or TPDES permit, the facility must analytically monitor storm water discharges from its facility during a representative storm event on an outfall-by-outfall basis at a frequency to be determined by Harris County for any pollutants Harris County determines the facility may be contributing to the MS4. Harris County will inform each facility of the parameter or parameters for which it must analyze and the applicable threshold for each parameter. Harris County will send written notification of its decision by certified mail, return receipt requested. All sampling conducted by a facility shall occur during a representative storm event and shall be completed within the first 30 minutes of discharge using a grab sample. If it is not practicable to complete the sampling within the first 30 minutes, sampling must be completed with the first hour of discharge. Upon request, the operator of the facility shall submit the results of any monitoring under this section to the Industrial Manager.

SECTION 2.02 – NO EXPOSURE CERTIFICATION

Type 1 and Type 2 Facilities and other Facilities with Storm Water Discharges Associated with Industrial Activity that are subject to the monitoring requirements in Part D, Section 2.01, may be excluded from those requirements if there is no exposure of individual materials or activities to precipitation or runoff. To qualify for a no exposure exclusion, Facilities with Storm Water Discharges Associated with Industrial Activity shall submit to the Industrial Manager a copy of the no exposure certification required to obtain coverage under the TCEQ Multi-Sector General Permit. Type 1 and Type 2 facilities that do not have Storm Water Discharges Associated with Industrial Activity may qualify for a no exposure exclusion by submitting to the Industrial Manager a no exposure certification on a form provided by the Industrial Manager.

A facility with Storm Water Discharges Associated with Industrial Activities that qualifies for a no exposure certification must obtain a permit to discharge as required in Part D, Section 1.02 before changing operating and management procedures that would result in exposure of storm water to industrial activities. A Type 1 or 2 facility that qualifies for no exposure certification

must notify the Industrial Manager in writing before changing operating or management procedures that would result in exposure of storm water to industrial activities.

It is a violation of these Regulations for a facility that has submitted the conditional no-exposure certification to fail to meet the no-exposure certification standards established by the TCEQ or Industrial Manager, as applicable.

SECTION 2.03 – REPORTING OF MONITORING RESULTS

All monitoring results shall be submitted according to the following:

- (a) If the results of any monitoring required under Part D, Section 2.01 above, exceed the thresholds established by Harris County pursuant to Part D, Section 2.01 (b or c), or a benchmark or effluent limitation in an NPDES or TPDES storm water permit for a facility, the owner and operator of the facility shall submit the results in writing to Harris County Pollution Control within thirty (30) days after conducting the monitoring.
- (b) If the results of any monitoring required by this section exceed the thresholds established by Harris County or a benchmark or effluent limitation in an NPDES or TPDES storm water permit, the owner or operator of the facility shall investigate the cause of the exceedance and take appropriate corrective action to eliminate the exceedance as soon as possible but no later than 30 days from when the exceedance is detected. The operator shall notify Harris County Pollution Control of the corrective measures that will be taken and a schedule for implementation.
- (c) Harris County Pollution Control may require additional monitoring at a frequency to be determined by Harris County and may require the submittal of monitoring data not specified in paragraphs (a) or (b) above. Additional monitoring, or the submittal of additional data, will be requested by Harris County Pollution Control in writing. It is a violation of these regulations to refuse to monitor or submit data as required above or as ordered by Harris County Pollution Control.

SECTION 2.04 – INTERMITTENT DISCHARGES

For intermittent discharges to the MS4, the discharger, upon request from Harris County, shall notify Harris County Pollution Control 24 hours prior to discharge, or as soon as is practicable.

Section 3 – Civil Enforcement

SECTION 3.01 – CIVIL ENFORCEMENT

If any person violates any section dealing with Storm Water Discharges Associated with Industrial Activity, the County Attorney may take whatever action is necessary to remedy the violation, including but not limited to filing suit for civil penalties up to \$1,000 a day for each violation, and to enjoin the violation. Each day a violation continues is considered a separate violation for purposes of assessing the civil penalty. Nothing in these Regulations precludes Harris County through the County Attorney's Office from seeking enforcement of state environmental laws pursuant to the Texas Water Code.

PART E – NON-STORM WATER DISCHARGES

Section 1 – In General

SECTION 1.01 – ADMINISTRATION

The Industrial Manager and Harris County Pollution Control are responsible for the administration of these Regulations dealing with non-storm water discharges, enforcement of these Regulations, and maintaining proper records.

SECTION 1.02 – NON-STORM WATER DISCHARGES PROHIBITED

- (a) No person shall discharge or cause to be discharged into the Municipal Separate Storm Sewer System (MS4) anything that is not composed entirely of storm water except the following:

1. A discharge authorized by, and in full compliance with, an NPDES or TPDES permit (other than an NPDES permit issued to a governmental entity for discharges from the MS4);
2. A discharge or flow resulting from fire fighting by the fire department if that discharge is not reasonably expected to be a significant source of pollutants to the MS4;
3. A discharge or flow of fire protection water if that discharge is not reasonably expected to be a significant source of pollutants to the MS4;
4. Water line flushing, provided the water contains less than or equal to 5.0 mg/l total chlorine when entering the MS4;
5. Landscape irrigation;
6. Diverted stream flows;
7. Rising Ground Waters;
8. Ground Water infiltration;
9. Infiltration, as defined at 40 CFR 35.2005(20) to separate storm sewers;
10. Pumped ground water;
11. Foundation drains;
12. Discharges from potable water sources, provided the water contains less than or equal to 5.0 mg/l total chlorine when entering the MS4;
13. Irrigation water;
14. Air conditioning condensation;
15. Water from crawl spaces;
16. Springs;
17. Lawn watering provided the water does not contain significant amounts of fertilizers, pesticides, herbicides, or other undesirable lawn care products;
18. Footing drains;
19. Flows from riparian habitats and wetlands;
20. Non-commercial car washing (until such time as the TCEQ issues a general permit for such discharges);

21. Pavement wash waters provided cleaning chemicals are not used or other significant contaminants are not present (until such time as the TCEQ issues a general permit for such discharges);
 22. Swimming pool discharges provided the water contains less than or equal to 5.0 mg/l total chlorine when entering the MS4;
 23. Materials resulting from a spill where the discharge is necessary to prevent loss of life, personal injury or severe property damage provided that the party responsible for the spill takes all reasonable steps to minimize or prevent any adverse effects to human health or the environment.
 24. Uncontaminated compressor condensate; and
 25. Traffic control device wash water provided cleaning chemicals or detergents are not used.
- (b) Harris County may determine, on a case-by-case basis, that any of the above listed discharges in subsection (a) are contributing a substantial pollutant loading to the MS4, and may prohibit such discharges according to the following:
1. Harris County will provide written notice that the discharge is prohibited;
 2. The person affected by this may appeal this decision according to Part E, Section 2 and obtain a variance according to Part E, Section 2.05. To appeal, the person must inform Harris County of its decision to appeal within 30 days after the receipt of notice from Harris County.
- (c) It is a violation of these Regulations if a person discharges any storm water that contains a pollutant or any substance which causes, continues to cause, or will cause pollution.

SECTION 1.03 – SPILLS INTO THE MS4

Any discharge into the MS4 subject to the reporting requirements of 30 TAC §319.302 or 30 TAC §327.3 shall be reported to Harris County Pollution Control at 713-920-2831, as soon as possible, and not later than 24 hours after the occurrence.

Section 2 – Appeals and Hearing Procedure, Variances, and Review by Commissioners Court

SECTION 2.01 – APPEALS

If Harris County determines that a facility is a Type 1 or Type 2 facility under Part D, Section 1.05 or that a discharge is contributing a substantial pollutant loading to the MS4 pursuant to Part E, Section 1.02 (b), the discharger may appeal the determination as provided in this Section. The term “appellant” is used to refer to the appealing party. An appellant must seek his remedy under this procedure before seeking his remedy in court. The appeals process is as follows:

- (a) Appeals are initiated by submitting a written challenge to Harris County’s determination to the Hearing Examiner.
- (b) The Hearing Examiner will set a time for a hearing, which will be scheduled as soon as practicable but within forty-five (45) days of the receipt of the written complaint or request, and shall prepare a Notice of Public Hearing naming the time and date of the Hearing. Copies shall be distributed as follows:
 - 1. The original copy and the Certificate to Commissioners Court will be filed with the Clerk of Commissioners Court and the Clerk will prepare a file for the Hearing Notice.
 - 2. The Examiner will set up his own working or hearing file, in which he will keep one copy.
 - 3. The Examiner will give one copy to the Appellant.
 - 4. The Examiner will deliver one copy to the Industrial Manager. The Hearing will be conducted as provided in Part E, Section 2.02.
- (c) Appeal of a determination that a discharge contributes a substantial pollutant loading to the MS4 will not abate the determination pending the decision of the Hearing Examiner.

SECTION 2.02 – HEARING BEFORE THE EXAMINER

At Hearings before the Examiner, the Examiner will hear the testimony of the Industrial Manager or Harris County Pollution Control and any witnesses called by the Industrial Manager or Harris County Pollution Control. The Examiner will hear the testimony of the appellant and any witnesses called by the appellant. The Examiner will review all documents and exhibits submitted to him by the parties. The Examiner will not be bound by formal rules of evidence and will control the

evidence, reserving to himself the power to exclude testimony or exhibits he does not consider relevant. The Hearing Examiner will maintain an accurate record of the evidence adduced at the Hearing.

SECTION 2.03 – FILING OF EXAMINER'S DECISION

The Examiner will prepare a written decision within three (3) working days of the Hearing. A copy of his decision will be filed with the Clerk of Commissioners Court, the members of the Commissioners Court, and with the Industrial Manager. The original will be sent to the appellant's address. If a variance is granted, the Industrial Manager shall prepare the appropriate paperwork requirements that may be required by the conditions of the variance.

SECTION 2.04 – REVIEW BY COMMISSIONERS COURT

If the Industrial Manager, Harris County Pollution Control, or the appellant wishes to appeal the Examiner's decision, a written objection must be filed with the Clerk of Commissioners Court within ten (10) days from the date the Examiner's decision is filed. The Clerk will notify the Hearing Examiner who will place the matter on the Agenda of Commissioners Court for review at the next meeting of Commissioners Court. If the Industrial Manager or Harris County Pollution Control files the objection, notice that the matter is on the agenda will be sent to the appellant by mail. Commissioners Court will review the matter. The Commissioners Court may either affirm or reverse the decision of the Hearing Examiner. The determination that the discharge contributes a substantial pollutant loading to the MS4 will not be abated pending the review of Commissioners Court.

SECTION 2.05 – VARIANCES

If any person wishes an exception to any provision of these Regulations, he or she shall request a variance in the manner prescribed for the filing of an appeal by Part E, Section 2.01, with the Hearing Examiner. The Hearing Examiner shall hold a hearing, and deny or grant the variance. Variances will be granted only if the conditions below are met:

- (a) The applicant has shown good and sufficient cause;

- (b) It has been determined that failure to grant the variance would result in an exceptional hardship to the applicant; and
- (c) The granting of a variance will not result in a substantial pollutant loading into the MS4, additional threats to public safety, extraordinary public expense, or create nuisances, cause fraud or victimization of the public.

Economic hardship shall not constitute the sole basis for granting a variance. A hearing before Commissioners Court regarding variances shall be requested in the manner provided in Part E, Section 2.04 of these Regulations. If a variance is granted the applicant may then discharge and shall conform to all applicable provisions of these Regulations except the section or sections for which a variance is granted.

Section 3 – Compliance Monitoring

SECTION 3.01 – COMPLIANCE MONITORING

Harris County may require the installation and maintenance of monitoring equipment according to the following:

- (a) Harris County shall have the right to install at a facility that discharges storm water to the MS4, or to require the installation of, such devices as are necessary to conduct sampling or metering of the facility's operations.
- (b) Harris County may require any facility that it determines has discharged or is discharging a pollutant or any substance which causes, continues to cause, or will cause pollution to conduct specified sampling, testing, analysis and other monitoring of its storm water discharges. Harris County may specify the frequency and parameters of any required monitoring.
- (c) Harris County may require any facility that it determines has discharged or is discharging a pollutant or any substance that causes, continues to cause, or will cause pollution to install monitoring equipment as necessary at the facility's expense. The facility, at its own expense, shall at all times maintain the sampling and monitoring equipment in a safe and proper operating condition. Each device used to measure storm water flow and quality must be calibrated to ensure accuracy.

- (d) Any temporary or permanent obstruction to safe and easy access to a facility that is to be inspected or sampled must be promptly removed by the facility at the written or verbal request of the Industrial Manager and may not be replaced. The cost of clearing the access to the facility must be borne by the facility.

Section 4 – Civil Enforcement

SECTION 4.01 – CIVIL ENFORCEMENT

If any person violates any section dealing with Non-storm Water Discharges, the County Attorney may take whatever action is necessary to remedy the violation, including but not limited to filing suit for civil penalties up to \$1,000 a day for each violation, and to enjoin the violation. Each day a violation continues is considered a separate violation for purposes of assessing the civil penalty. Nothing in these Regulations precludes Harris County through the County Attorney's Office from seeking enforcement of state environmental laws pursuant to the Texas Water Code.

APPENDIX A

Minimum Design Criteria for Implementation of Certain Best Management Practices for Storm Water Runoff Treatment Options

**Minimum Design Criteria for
Implementation of Certain Best
Management Practices for Storm
Water Runoff Treatment Options**

2001 Edition

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INTRODUCTION

Background

As a part of the NPDES storm water permit requirements, the Joint Task Force (JTF), drafted and adopted the *Storm Water Quality Management Guidance Manual (October 2000)*, “Guidance Manual.” The Guidance Manual provides planning-level guidance on several Best Management Practices (BMPs) that may be suitable in Houston and Harris County, and incorporates additional BMPs by reference.

During the public review of the Guidance Manual, several comments were received requesting design-level information for the structural BMPs included in the Guidance Manual. Non-structural BMPs are discussed in Chapter 4.1 of the Guidance Manual. This document, *Minimum Design Criteria for Implementation of Certain Best Management Practices for Storm Water Runoff Treatment Options (2001 Edition)*, was prepared to address the public comments and provide design-level criteria for certain structural BMPs. It is intended to supplement the structural BMP information material provided in the Guidance Manual. The information contained in this document is adapted from several other manuals prepared in other parts of the USA. Sources are listed in the reference section of this document.

Purpose

The purpose of this document is to provide minimum design parameters for certain BMPs for storm water quality features for new development and significant redevelopment. Use of the BMPs presented here does not guarantee acceptance of a particular Storm Water Quality Management Plan or effectiveness of the BMP to reduce pollutants. The BMPs described in the criteria document are intended to facilitate the plan review process for new development and significant redevelopment projects in the City of Houston and unincorporated Harris County.

Organization

This document contains design-level criteria and design detail drawings for five structural BMPs, where each BMP has an identifier code composed of letters and numbers. The document will be revised and updated as necessary to include additional BMPs. Other BMPs may be acceptable on a case-by-case basis. In such cases prior consultation with the reviewing agency is highly recommended. This document provides design-level criteria on the BMPs listed below:

- Grass Swales
- Vegetated Filter Strips
- Wet Pond
- Dry Detention Basins
- Constructed Wetlands for Storm Water Treatment

Grass Swales

BMP HC01.10

Grass Swales

Purpose and Definition

Grass swales are defined as grass-lined, earthen channels, intended to provide water quality enhancements. Grass swales provide effective treatment only when they have low longitudinal slopes, with low velocities and shallow depth of flow in the swale. The main pollutant removal mechanisms in grass swales are filtration as the storm water moves through the vegetation and bacterial decomposition. Careful selections of grass species that allow more contact with microorganisms living on the vegetation enhance pollutant removal of grass swales.

Application and Limitations

Grass swales are applicable best management practices where the peak flow rates and velocities are low. They are recommended as a stand-alone best management practices for areas draining 10 acres or less and where pollutant concentration from the area is low. In developments draining more than 10-acres, grass swales could be used in combination with other best management practices.

Design Criteria

The primary design factors that determine grass swales' effectiveness are peak flow rate, depth of flow, and height of vegetation. The design should promote pollutant removal rather than transporting flow with greater possible hydraulic efficiency. Therefore, it is critical that filtration, sedimentation, and other pollutant removal mechanisms are emphasized.

Grass swales for water quality enhancements should be sized to treat the flow generated by the design rainfall intensity from the drainage area. *Table 1.1* summarizes the design criteria for grass swales and *Figure 1* depicts a typical layout of a grass swale. Based on the analysis of the 1-hour precipitation data of rainfall gauges in the Harris County area, an intensity of 0.27-inch per hour was computed for 90 percent of the storms. Unless amended by additional rainfall data analysis the design flow shall be calculated using an intensity of 0.27-inch per hour. The rational formula ($Q=CIA$) shall be used to determine the design flow rate. The flow velocity shall not exceed 1.5 feet per second. The longitudinal slope of the swale shall not exceed 2 percent and the minimum slope shall be 0.1 percent. Because of site condition, if the desired slope could not be attained, check dams shall be used as small drop structures to achieve the desired swale slope. The check dams should be reinforced adequately for erosion protection. The design of grass swales must encourage sheet flow of storm water within the swale. If sheet flow conditions cannot be achieved, a flow spreader (*Figure 1-A*) must be installed to uniformly

spread the flow across the width of the swale. The width of the swale shall be sized to achieve a depth of flow, in the grass swale, of 3 inches or half the height of the grass, whichever is less. *Table 1.2* summarizes recommended plant list for grass swales. A more comprehensive plant list is provided in the Guidance Manuals Appendix E. The design storm shall travel for at least 50 feet on the grass swale for water quality treatment before its discharge into the receiving stream or municipal storm sewer system. The length of swale should be calculated based on a minimum hydraulic retention time of 5 minutes. Discharges from the grass swale to a receiving stream or roadside ditch shall not promote erosion, and erosion prevention devices shall be constructed. The side slope of the swale shall be 3H:1V or flatter.

Sizing Procedure

- Determine the drainage area (A) of the site that drains into the grass swales.
- Determine the runoff coefficient (C) of the development. Runoff coefficient values from the City of Houston Design Manual, Chapter 9 - Storm Water Design Requirements, shall be used.
- Based on the design storm, calculate design flow rate (Q_{wq}) from the drainage area using the rational formula.

$$Q_{wq} = CIA$$

Where:

Q_{wq} = Water quality design flow rate (ft³/sec)

C = Runoff coefficient (dimensionless)

I = Intensity (in/hr)

A = Area in (acres)

- The Manning's roughness coefficient (n) for the swale shall be 0.24 for frequently mowed grass with a height of 6 inches.
- Determine the longitudinal swale slope (S).
- Determine the depth of flow (d). Depth of flow shall be 3 inches or half the grass height, whichever is less.
- Select a channel shape and a side slope (z).
- Using Manning's equation, determine the bottom width (b) of the swale by trial and error or use the approximate method given below. Substitute the value of Q_{wq} calculated above for Q in the

Manning's equation.

$$Q = \frac{1.49}{n} AR^{2/3} S^{1/2}$$

Where:

Q = Water quality design flow rate ft³/sec

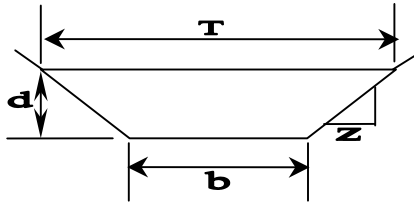
n = Manning's roughness coefficient (dimensionless)

A = Cross-sectional area (ft²)

R = Hydraulic radius (ft)

S = Longitudinal slope (dimensionless)

Basic hydraulic equations and cross sectional formula for a trapezoidal shape:



$$A = bd + zd^2$$

$$P = b + 2d\sqrt{z^2 + 1}$$

$$R = \frac{A}{P}$$

$$T = b + 2zd$$

By recognizing that top width (T) is much greater than depth of flow (d) and the square of the side slope (z^2) is much greater than 1 and certain terms are negligible the approximate solution to determine the bottom width of a trapezoidal shape is:

$$b \approx \frac{Qn}{1.49d^{1.67}S^{0.5}} - zd$$

- Calculate the cross-sectional flow area.
- Calculate velocity of flow (V), and if velocity of flow exceeds the recommended maximum, recalculate the bottom width of the swale.
- Determine the length of the grass swale based on a minimum hydraulic retention time of 5 minutes (300 seconds). The required minimum swale length is 50 feet.

$$L = V \times t$$

Where:

V = velocity in feet per second

t = hydraulic retention time 300 seconds

Maintenance

Maintenance is the most important factor if water quality grass swales are to continue to function as originally designed.

- Until grass is established, grass swales must be inspected within 24 hours after each storm of 0.5 inch or greater or daily during prolonged rainfall events.
- After grass has been established, the swale should be checked at least monthly.
- The grass must be mowed as needed for good growth and to maintain the desired grass height. A maximum grass height of 6 inches shall be maintained.
- Sediment must be removed as needed if growth is inhibited in greater than 10 percent of the swale area or if sediment is blocking the distribution and entry of the storm water runoff.

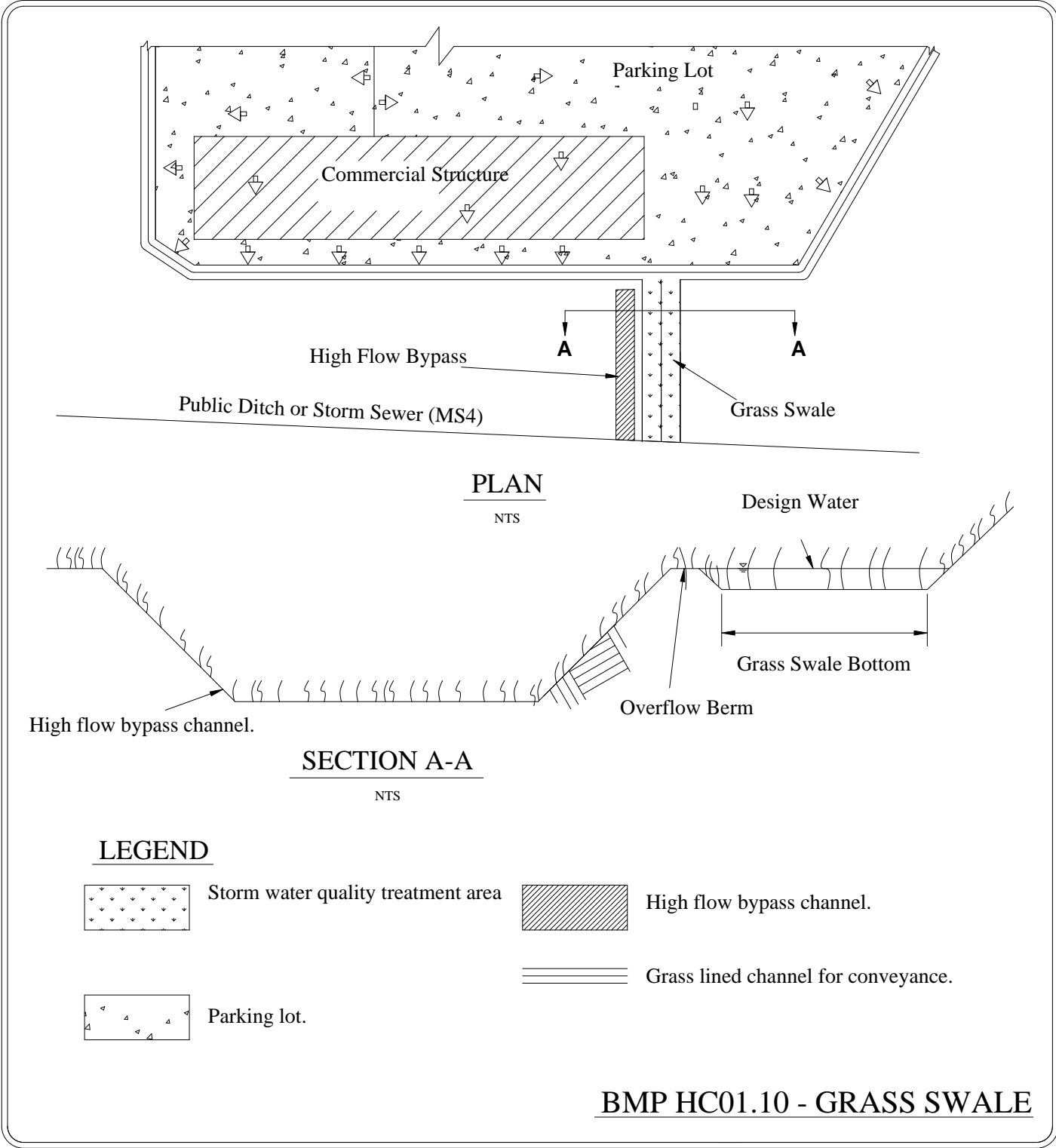
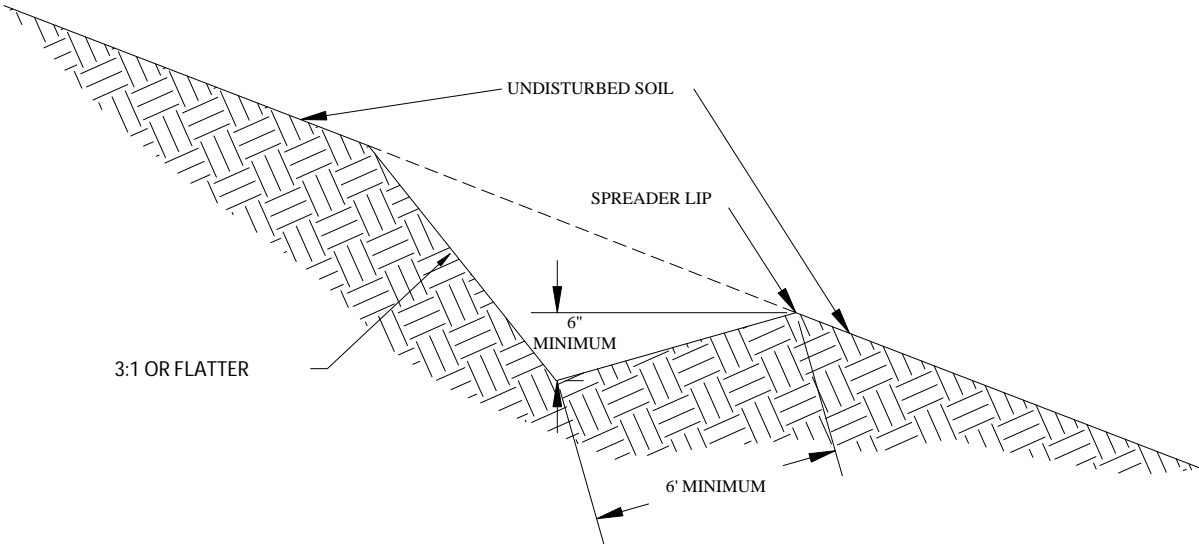
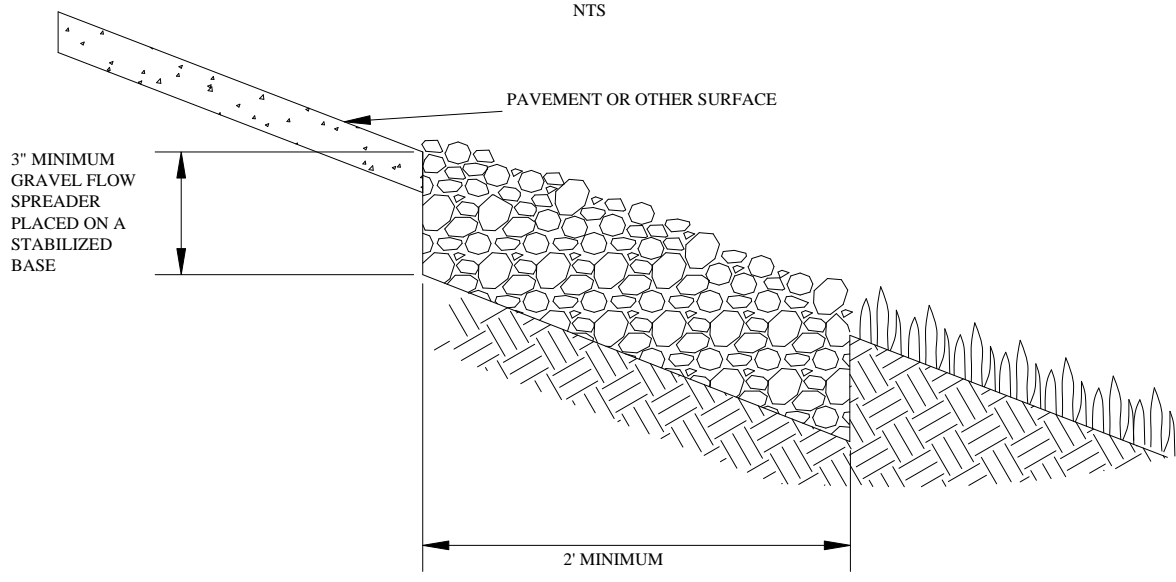


Figure 1: Grass Swale Sample Layout



LEVEL SPREADER 1
TYPICAL SECTION
 NTS



LEVEL SPREADER 2
TYPICAL SECTION
 NTS

BMP HC01.10 - LEVEL SPREADER

Figure 1-A: Level Spreader

Table 1.1: Sizing Criteria for Grass Swales

Design Parameters	Grass Swales¹
Longitudinal slope ²	Less than 2% with a minimum of 0.1%
Maximum velocity	1.5 feet per second
Maximum water depth	3 inches or half the grass height, which ever is less
Water quality design flow rate	Calculate using rational method using 0.27 in/hr rainfall intensity
Manning coefficient	0.24
Bottom width	Size to satisfy depth and flow velocity
Minimum length	50 feet
Maximum side slope	3H:1V
Contributing drainage area	Less than 10 acres
Hydraulic resident time	5 minutes (300 seconds)

¹Easement or restricted reserve dedication must contain wording that references the file number (permit number) and the public entity that holds the plan. The plan must include the maintenance schedule and frequency. Grass swales designed for water quality purposes **CANNOT** be used for drainage conveyance. A separate drainage conveyance should be provided based on the applicable agency criteria.

²If site conditions do not allow a 2% longitudinal slope, check dams must be used as drop structures to achieve the desired slope. The check dams shall be designed with adequate erosion protection.

Table 1.2: Recommended Plants for Grass Swales

Scientific Name	Common Name	Expected Growth Height	Method of Planting ¹
Carex cherokeensis	Cherokee sedge ²	4 to 6 inches	Plug
Eleocharis macrostachys	Spikerush	2 to 4 inches	Rhizome/plug
Eleocharis montevidensis	Sand spikerush	2 to 4 inches	Rhizome/plug
Juncus effusus	Soft rush	18 inches to 4 feet	Rhizome/plug
Juncus nodatus	Stout rush	2 to 4 feet	Rhizome/plug
Juncus interior	Inland rush	1 to 3 feet	Plug
Juncus torreyi	Torrey's rush	1 to 3 feet	Plug
Sisyrinchium (sp.)	Blue-eye grass	Up to 4 inches	Seed
Buchloe dactyloides	Buffalograss	2 to 4 inches	Seed

¹Quantities must be determined based on area of planting

²Tolerate shady areas

**Sample Calculation for Sizing Grass Swales
Design Steps**

1. Determine the drainage area of the development. For this example a 5-acre residential development was selected.
2. Determine the runoff coefficient of the development. For this example, a runoff coefficient of 0.45 was selected for single-family medium density residential development based on the City of Houston Design Manual.
3. Based on the design storm, calculate flow rate from the drainage area. For this example, 0.27 in/hr intensity was used to calculate flow rate using the rational formula.

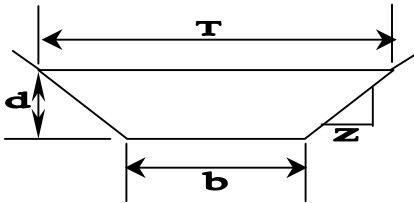
$$Q = CIA$$

$$Q = 0.45 * 0.27 \frac{\text{in}}{\text{hr}} * 5 \text{ acres} = 0.61 \frac{\text{ft}^3}{\text{sec}}$$

4. For a grass lined swale use a Manning's roughness coefficient of 0.24 as required.
5. Determine the grass height based on frequency of mowing. The maximum recommended height is 6 inches. For this example a height of 6 inches is selected.
6. Determine depth of flow. Depth of flow in the grass swale shall be 3 inches or half the grass height, whichever is less. For this example the depth of flow is 3 inches (0.25 feet).

7. Select the shape of grass swale and side slope. For this example a trapezoidal channel with a side slope of 4H:1V is selected.
8. Select the longitudinal slope of the grass swale. For this example a 1 percent slope is selected.

Basic hydraulic equations and cross sectional formula



$$A = bd + zd^2$$

$$P = b + 2d\sqrt{z^2 + 1}$$

$$R = \frac{A}{P}$$

$$T = b + 2zd$$

$$b \approx \frac{Qn}{1.49d^{1.67}S^{0.5}} - zd$$

$$c=0.45$$

$$A=5 \text{ acres}$$

$$i=0.27 \text{ in/hr}$$

$$Q=0.61 \text{ ft}^3/\text{sec}$$

$$d=3 \text{ inch (0.25 ft)}$$

$$z=4$$

$$s=0.01$$

$$n=0.24$$

- Using the above equation

$$b \approx 9 \text{ feet}$$

- Calculate the cross sectional area

$$A = bd + zd^2 \quad A = 9 * 0.25 + 4 * 0.25^2 = 2.5 \text{ ft}^2$$

- Calculate the flow velocity

$$V = \frac{Q}{A} = 0.24 \text{ ft/sec}$$

The calculated velocity is less than the recommend maximum velocity of 1.5 feet/second. The design is adequate.

Calculate the length (L)

$$L = Vt(60 \text{ sec/min})$$

For t=5 minutes (300 seconds),

$$L = 0.24 \text{ ft/sec} * 300 \text{ seconds} = 73 \text{ feet}$$

Based on the above calculation the design parameters for the trapezoidal section grass swales are:

- Bottom width 9 feet
- Length 73 feet
- Depth 0.25 feet
- Side slope 4H:1V

Filter Strips

BMP HC01.20

Vegetated Filter Strips

Purpose and Definition

Filter strips are a vegetative structural control intended to treat sheet flow. Filter strips provide effective treatment only when they have low slopes and where velocities are low. The design of filter strips should promote sheet flow of storm water runoff. The length of filter strip is the treatment media where most of the pollutants are trapped through filtration, sedimentation, sorption, and bacterial decompositions as the storm water sheet flows. Grass species, that allow more contact with the storm water, enhance pollutant removal performance; therefore, selection of grass species must be done carefully.

Application and Limitations

Filter strips are suitable best management practices where the peak flow rates and flow velocities are low, and sheet flow conditions prevail. If sheet flow condition cannot be achieved, a level spreader should be provided to facilitate sheet flow onto the filter strips. They are recommended as a best management practices for areas draining 10 acres or less. In developments draining more than 10 acres, filter strips could be used as a supplement with other best management practices. Filter strips are relatively flat with no side slopes and are typically located adjacent and parallel to paved areas such as parking lots, driveways, and roadways.

Design Criteria

The primary design factor that determines filter strip effectiveness is flow rate, flow velocity, and prevailing flow condition. The design criteria for filter strips are summarized in *Table 1.4*. The length of the filter strip and the length of the area that generates sheet flow are important design parameters. The filter strip length required is discussed below, and an example of filter strip is found in *Figure 2*.

- The minimum width of the filter strip shall be 20 feet. For areas that have a flow path of less than 60 feet, the minimum 20 feet filter strip shall be provided.
- For areas that have a flow path greater than 60 feet, an additional 5 feet of vegetation width shall be added for each additional 20 feet or fraction thereof. The maximum flow path of the paved surface shall not be more than 150 feet. *Table 1.3* summarizes the required filter strip width for areas that have flow paths from 60 to 150 feet.

Table 1.3: Flow Path and Required Filter Strip Width

Flow Path Across the Paved Surface, feet	Filter Strip Width, feet
<60	20
60 to 80	25
80 to 100	30
100 to 120	35
120 to 140	40
140 to 150	45

- Dense growth vegetation is required, and the filter strip shall be constructed along the entire length of the contributing area.

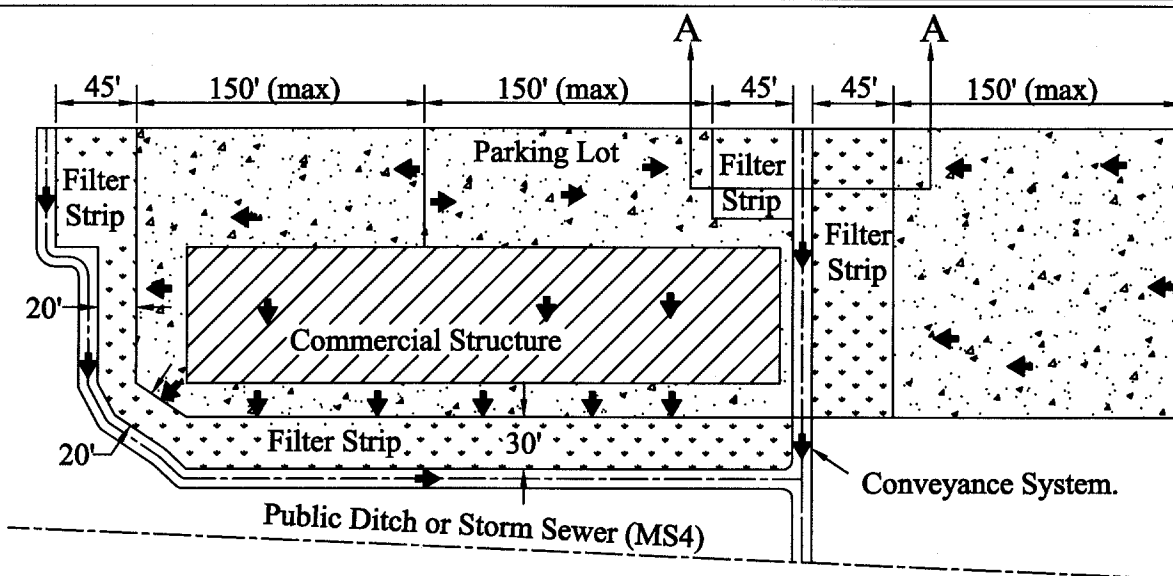
Maintenance

Maintenance is the most important factor if water quality filter strips are to continue to function as designed. The maintenance requirement of filter strips is similar to grass swales.

Table 1.4: Sizing Criteria for Filter Strips

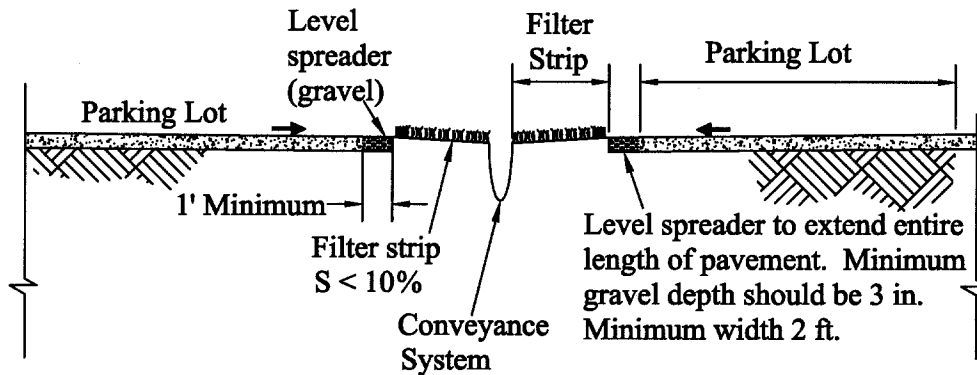
Design Parameters	Filter Strips¹
Longitudinal slope	Less than 10% with a minimum of 0.1%
Maximum velocity	1.0 feet per second
Maximum water depth	1 inch maximum
Water quality design flow rate	NA
Manning coefficient	NA
Bottom width	NA
Minimum length	20 feet filter strip width for flow path up to 60 feet; an additional 5 feet of filter strip width shall be added for each additional 20 feet or fraction thereof
Maximum drainage pathway	150 feet (across paved area)
Maximum side slope	NA
Contributing drainage area	Less than 10 acres

¹Easement or restricted reserve dedication must contain wording that references the file number (permit number) and the public entity that holds the plan. The plan must include the maintenance schedule and frequency.



PLAN

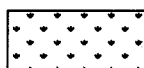
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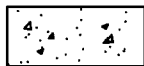
SECTION A-A

NTS

LEGEND



Storm water quality treatment area must be encumbered by easement or restricted reserve and recorded at Harris County.



Parking lot.

BMP HC01.20 - VEGETATED FILTER STRIP

Figure 2: Vegetated Filter Strip Example Design Layout

Sample Calculation for Sizing Filter Strips

Design Steps

- 1 Determine the flow path that needs to be serviced. For this example, a 300 feet wide parking lot with varying length is selected.
- 2 Calculate the required filter strip width. A 45 feet wide filter strip is needed for 150 feet paved area.
- 3 Select plants appropriate for the project site conditions. For this example Buffalo grass with a mix of Meadow sedge, Cherokee sedge, and Blue eyed grass are selected.

Wet Pond

BMP HC01.30

Wet Pond

Purpose and Definition

A wet pond is a constructed storm water treatment facility that retains a permanent pool of water. The permanent pool area enhances storm water runoff by gravitational settling, and plants in the fringe areas of the wet pond remove nutrients. Bacterial action in the water helps in chemical decomposition of complex substances into simpler forms.

Application and Limitations

Wet ponds are one of the most effective BMPs to enhance the quality of storm water runoff. The wet pond permanent pool is designed to hold and treat the design runoff for water quality enhancements between storm events through quiescent settling and biological uptake. In areas where soil permeability is high, water seepage from unlined ponds could result in a dry pond, particularly in dry seasons. Lining the bottom and the sides of the ponds with low permeable material helps to reduce seepage and maintain the design permanent pool volume. If wet ponds are used in areas with insufficient runoff, a supplemental water source may be necessary.

Wet ponds may be a single purpose facility to provide water quality treatment or they may serve multiple functions by providing flood control storage or recreational facilities. Wet ponds can be designed to have different storage stages, including the bottom stage permanent pool, extended detention, and flood protection storage. When combined with flood control function, the permanent pool is stacked under the extended detention and flood protection storage with potentially little loss of developable area.

Design Criteria

Several design factors determine the effectiveness of wet ponds. These factors include permanent pool volume, hydraulic residence time, pond geometry, pond depth, forebay (pre-settling), and permanent pool surface area. *Table 1.5* summarizes the design parameter for wet pond design. The presence of aquatic vegetation also may improve storm water quality. Other design considerations include a liner to prevent seepage, overflow and emergency spillways, berm embankments or slope stabilization, and maintenance drains. For a basic wet pond without extended detention, the volume of the permanent pool shall be equal to or greater than the total volume of runoff from the water quality design storm. *Figure 3 and 3-A* show examples of the layout and cross-sections of a wet pond. *Figure 3-C* shows details of the riser outlet with trash protection.

Permanent Pool Volume

The permanent pool volume shall be 0.5 inch of runoff from the drainage area. The permanent pool should remain full at all times to provide a source of water for wetland plants at the fringe of the wet pond and minimize turbulence within the pond. During storm events, the pond is designed to flush out the treated water and replace it with the incoming runoff. The permanent pool also minimizes re-suspension of sediments.

Hydraulic Residence Time

The hydraulic residence time (HRT) is the period of time a storm water runoff stays in the treatment system. Nationally, a time of two weeks has been shown to be sufficient to provide desirable storm water quality.

Pond Geometry

A length-to-width ratio of 3:1 or more shall be used to promote “plug flow,” (Plug flow describes the hypothetical condition of storm water moving through the pond as a unit where the incoming storm water displacing the existing storm water) and minimize short-circuiting and dead storage area. Ponds that have good distance separation between the inlet and outlet locations are less prone to short-circuiting. Short-circuiting occurs when incoming runoff passes through the pond without adequate treatment. Short-circuiting can be prevented by maximizing the distance between the pond inlet and outlet locations or by increasing the travel time within the basin. This type of design encourages the incoming storm water to displace the existing water in the permanent pool. An alternative method of achieving plug flow characteristics is to construct baffles within the pond to lengthen the flow path between the inlet and outlet.

Permanent Pool Depth

The permanent pool depth of the open water area shall be 3 to 6 feet deep. Permanent pool depth is an important design parameter, since most of the pollutant removal is accomplished by gradual settling. Extremely shallow basins, those that are less than 2 feet deep and without aquatic vegetation, are prone to re-suspension problems. Depths of more than 8 feet are not recommended because of thermal stratification of the pond. Basins with variable depths that contain both shallow areas of less than 2 feet for aquatic vegetation growth and deeper areas of greater than 3 feet may be most beneficial for water quality improvements. In shallow areas of the ponds, the emergent aquatic vegetation enhances nutrient uptake, whereas the deeper areas provide pollutant removal by gravitational settling. The vegetative bench area, if provided, shall be shallower than 3 feet.

Permanent Pool Surface Area

The permanent pool surface area is usually expressed as a percentage of the drainage area. It is recommended that the permanent pool surface area of a wet pond be at least 1 to 1.5 percent of the drainage area. Pollutant removal by sedimentation is a function of the surface loading rate and the amount of pollutant per unit surface area of the pond. Since sedimentation is the primary pollutant removal mechanism in wet ponds, the surface area of the pond plays an important role in enhancing pollutant removal.

Sediment Forebay

Sediment forebay is a required element of a wet pond design. The sediment forebay volume shall be 20 percent of the permanent pool volume, and the main pool shall contain the remaining water quality design volume. The depth of the sediment forebay shall be 4 to 6 feet. A tear shaped sediment forebay with length to average width ratio of 3:1, with the inlet at the narrow end is recommended. All inlets to the basin must first enter a sediment forebay. If desired, multiple sediment forebays can be used. A maintenance access must be provided. The forebay shall be designed to dissipate the energy and reduce the velocity.

Basin Configuration

Wet ponds can be designed to have different storage stages, including the bottom stage permanent pool, extended detention, and flooding protection storage. These types of basins are referred to as multi-purpose basins, and the permanent pool is stacked under the extended detention and flood protection storage. A multi-use wet pond outlet such as an emergency spillway, and outlet for storm water quantity control should be designed based on the applicable agency's drainage criteria.

Safety Bench

Safety bench area could be dry above the permanent pool or a shallow vegetative bench area below the permanent pool, *Figure 3-B*. A safety bench 10 feet wide and slope of 1 to 2 percent shall be provided above the permanent pool elevation of the wet pond. If the wet pond is designed with a combined vegetative/safety bench area, the safety bench shall be at least 6 feet wide, to facilitate mowing. The remaining 4 feet shall be vegetative bench area below the permanent pool.

Vegetative Bench

If only a vegetative bench area is included along the perimeter of the wet pond, the width shall be a minimum of 10 feet, *Figure 3-B*. This width includes the safety bench area with 10 percent slopes or flatter. The maximum depth of the vegetative bench shall be 3 feet. Both the sediment forebay and the main pool could have vegetative benches.

Providing vegetative bench adds aesthetics to the site and enhances pollutant removal. The total surface area of the vegetative bench should be approximately 20 to 30 percent of the permanent pool surface area.

Sizing Procedure

- Determine the drainage area (A) that contributes runoff to the pond.
- Determine the permanent pool volume (V_{pp}), which is 0.5 inch of runoff from the drainage area.
- Calculate the volume of the pre-settling basin or forebay (V_f) and the main pool (V_m). $V_f = 0.2 \times V_{wq}$ and $V_m = 0.8 \times V_{wq}$
- Design the pond layout to achieve the length to width ratio of at least 3L:1W. The pond layout shall maximize the flow path between the inlet and the outlet, minimize short-circuiting, and avoid dead storage area.
- Select a side slope based on the site condition. A side slope of 3H:1V or flatter is required for earthen ponds.
- Prepare a pond grading plan (establish contours) and capacity-elevation table of the pond.
- Determine the depth (d) and the surface area of the permanent pool (S), and set the water surface elevation of the permanent pool.
- Calculate water quality treatment volume (V_{wq}) which is 0.5 inch of runoff from the drainage area.
- Using the capacity-elevation table of the pond, determine the water quality volume elevation assuming that all of the water quality volume will be in the pond at once.
- Determine the average release rate assuming the water quality volume is released within 24 hours i.e., 0.021 cubic feet per second per drained acre.
- Calculate the average head (ΔH) from the elevation difference between the water quality and permanent pool elevations.
- Size an outlet based on the values calculated from the two procedures listed above, see sample calculation for further detail. Specify equation used.
- Specify overflow device such as emergency spillway and overflow elevation.
- Calculate the area of the permanent pool to be planted with wetland vegetation. This area is 20 to 30 percent of the permanent pool area.
- Consult a wetland specialist for wetland plant selections suitable to the project site.
- Specify floatables control or trash trap devices.

Maintenance

Maintenance is an important factor if water quality wet ponds are to continue to function as originally designed. A specific maintenance plan shall be prepared outlining the schedule and scope of maintenance operation. This plan should be included in the Storm Water Quality Management Plan and submitted to the applicable agency. The maintenance plan should include at a minimum:

- Inspection frequency, removal of floating debris and accumulated petroleum products.
- Removal frequency and method of disposal of sediments from the sediment forebay.
- Maintenance and management of the aquatic vegetation and aesthetic appearance of the site.
- Control of invasive plants and mowing.

Table 1. 5: Sizing Criteria for Wet Ponds

Design Parameters	Wet Pond¹
Permanent pool volume	0.5 inch of runoff from the drainage area
Water quality treatment volume	0.5 inch of runoff from the drainage area
Permanent pool depth	3 feet min. and 6 feet max.
Pond geometry or length (L) to width (W) ratio ²	Length to width ratio of 3L:1W or more; avoid dead storage areas and minimize short-circuiting
Side slope	3H:1V or flatter for earthen and no minimum for concrete
Vegetative shelf	20 to 30 percent of the permanent pool with depth less than 3 feet
Volume of pre-settling basin or forebay ³	20 percent of the permanent pool volume; 4 to 6 feet deep
Safety bench	Minimum of 10 feet wide without vegetative shelf area or 6 feet wide with vegetative shelf area above the permanent pool elevation.
Pond configurations (stages)	Multi stages for extended detention and flood control allowed
Distance between inlet and outlet	Placed to maximize flow path and without causing short-circuiting.
Outlet	Size to meet extended detention storage

¹Easement or restricted reserve dedication must contain wording that references the file number (permit number) and the public entity that holds the plan. The plan must include the maintenance schedule and frequency.

²For wet ponds, the flowpath length from inlet to outlet should be measured at deepest and the width at deepest can be found as (average top width + average bottom width)/2.

³All inlets that convey storm water runoff shall enter first the forebay or pre-treatment basin.

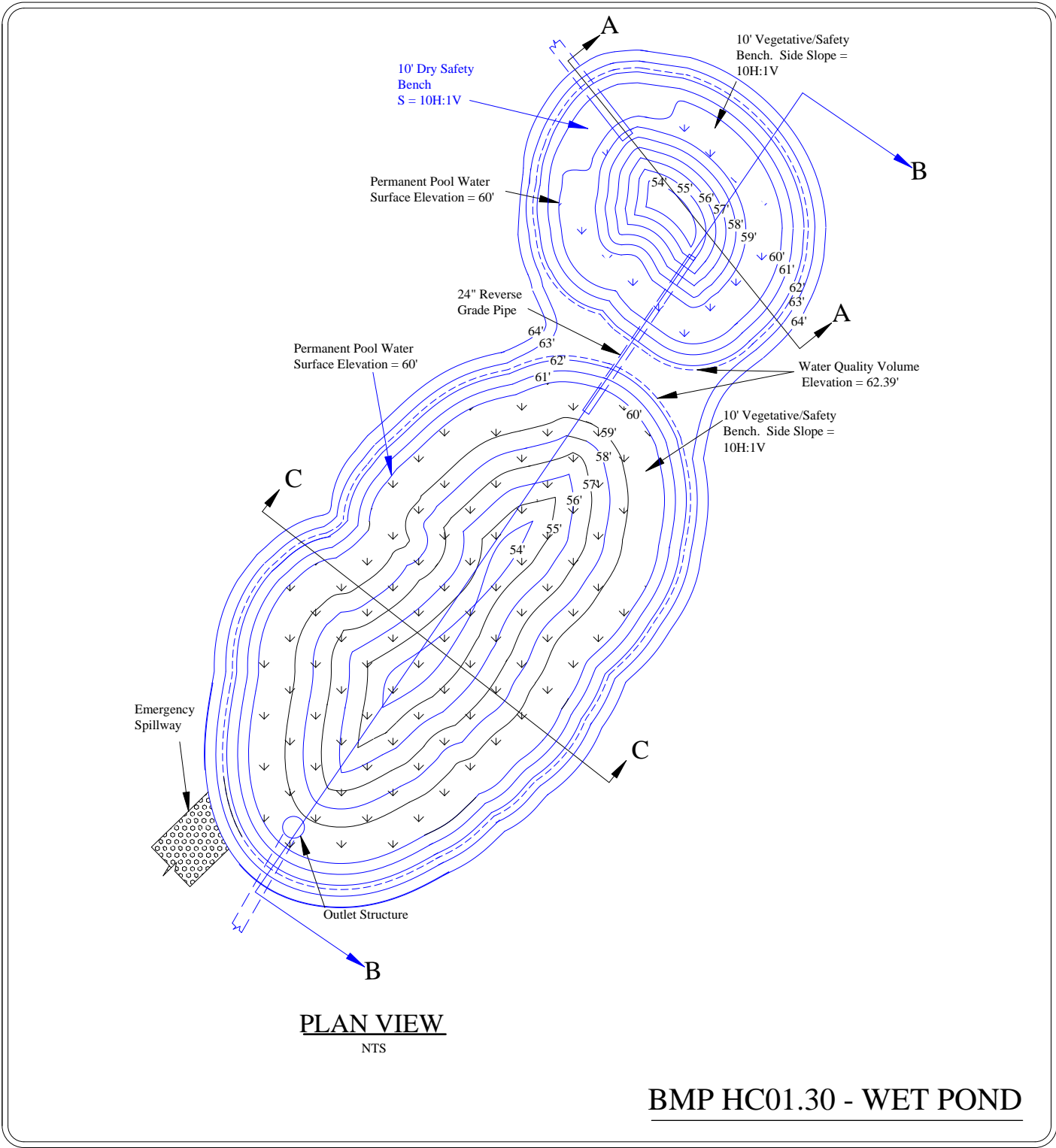
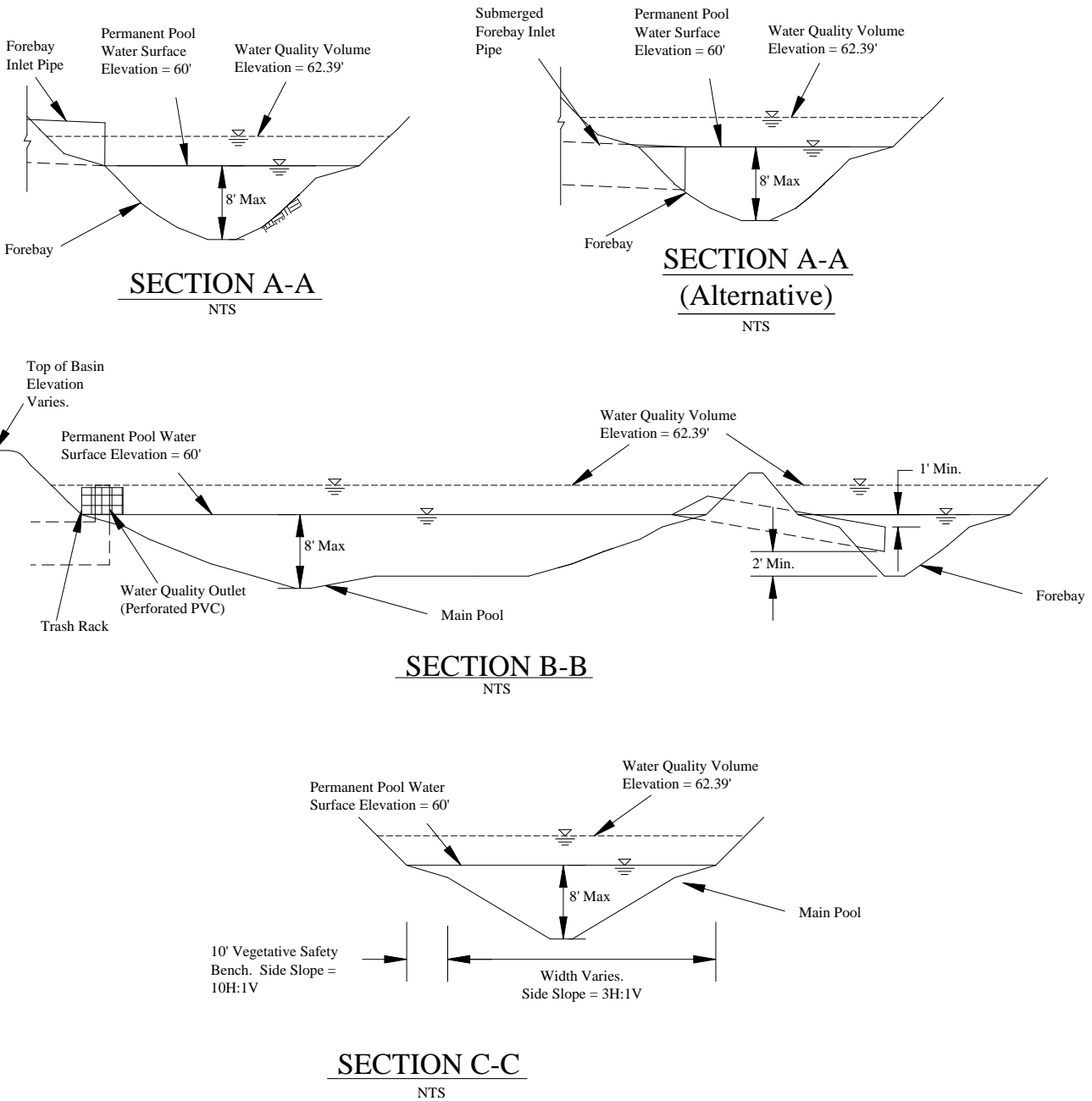
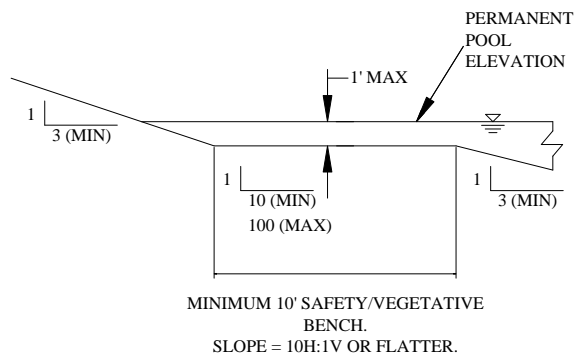


Figure 3: Wet Pond Example Design Layout

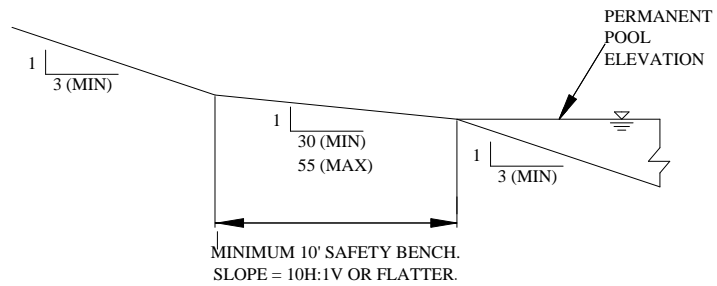


BMP HC01.30 - WET POND

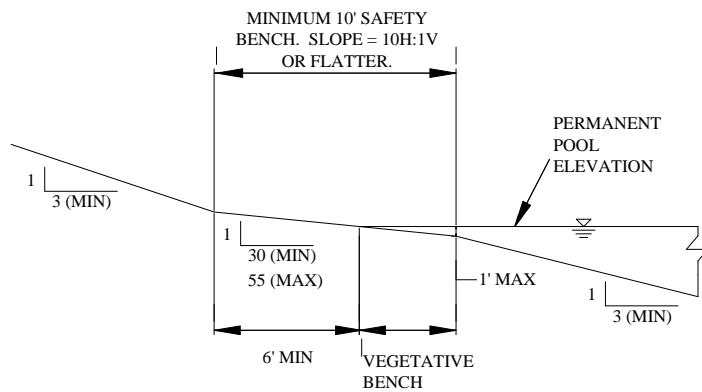
Figure 3-A: Wet Pond Example Cross-Sections



VEGETATIVE BENCH
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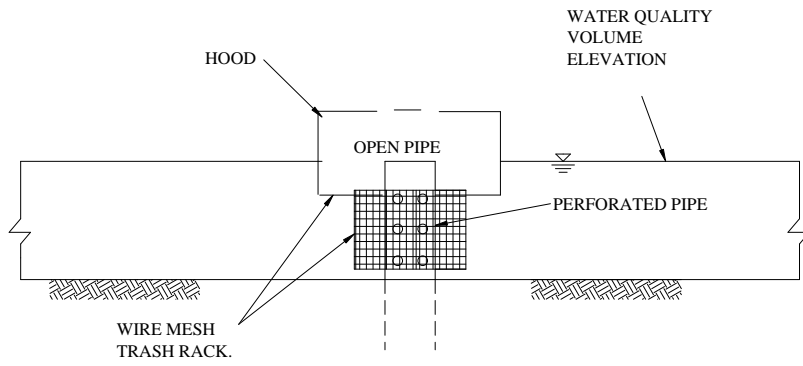
DRY SAFETY BENCH
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COMBINED VEGETATIVE AND DRY SAFETY BENCH
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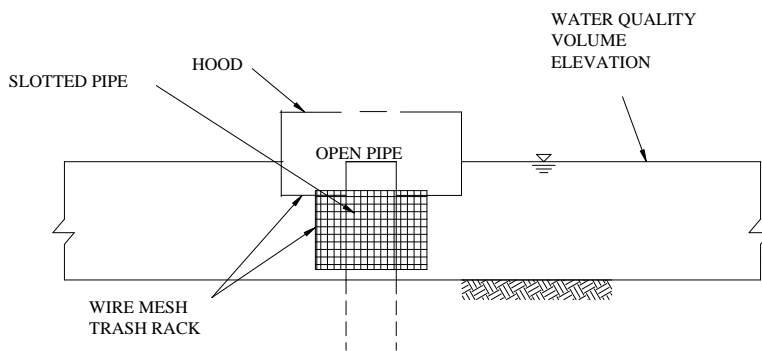
BMP HC01.30 - SAFETY/VEGETATIVE BENCH

Figure 3-B: Wet Pond - Safety and Vegetative Bench Cross-Sections



PERFORATED RISER
NTS

- WIRE MESH TRASH RACK NOTES:
1. WIRE MESH MUST BE FINER THAN PERFORATION DIAMETER OR SLOT WIDTH.
 2. DISTANCE BETWEEN SIDES OF WIRE MESH RACK MUST BE 3 TIMES THE PERFORATION DIAMETER OR GREATER.



SLOTTED RISER
NTS

BMP HC01.30 - RISER OUTLET

Figure 3-C: Wet Pond - Riser Outlet With Trash Protection

Sample Calculation for Sizing Wet Ponds

Design Steps

- 1 Determine the drainage area that contributes storm runoff. For this example a 20-acre site is selected and all of the area drains into the wet pond. It was assumed that the underling soil is acceptable to support a wet pond without lining and the water table at the site is below the lowest elevation of the wet pond.

- 2 Compute the permanent pool volume. The permanent pool volume is 0.5" of runoff from the drainage area, which is 0.83 acre-feet.

$$V_{pp} = 0.5 \text{ in} \times \frac{1 \text{ ft}}{12 \text{ in}} \times 20 \text{ acres} = 0.83 \text{ acre} - \text{feet}$$

- 3 Compute the forebay and the main pool volumes. For this example the forebay volume is 20 percent of the permanent pool volume and the remaining 80 percent is the main pool volume. Forebay volume is 0.17 acre-feet and the main pool volume is 0.66 acre-feet.

$$\text{Forebay volume } V_f = V_{pp} \times 0.20 \Rightarrow 0.83 \times 0.20 = 0.17 \text{ acre-feet}$$

$$\text{Main pool } V_m = V_{pp} \times 0.80 \Rightarrow 0.83 \times 0.80 = 0.66 \text{ acre-feet}$$

- 4 Layout the pond with approximate length to width ratio of at least 3:1. In the main pool at the widest point, the pond depth was set at 6 feet. The slope in both directions was 5:1 for 27 feet then it transitions to a 10-foot wide safety bench and vegetative shelf area with a 10:1 side slope. Based on these dimensions the assumed average depth was calculated to be approximately 3 feet. Length of the forebay is 61 feet and length of the main pool is 154 feet. The surface area of the forebay is 0.07 acres and the surface area of the main pool is 0.21 acres. The average width of the forebay and the main pool is calculated as 55 feet.
- 5 Compute the water quality treatment volume using 0.5" of runoff from the drainage area (0.83 acre-feet). Based on the layout and grading of the pond this volume creates a head of 2.39 feet above the permanent pool elevation.
- 6 Calculate the orifice area required to drain the water quality treatment volume within 24-hours. Using the following equation from Guidance Manual Page 4-38:

$$A_p = \frac{V_{wq}}{120.3 \times \Delta t \sqrt{\Delta H}}$$

Where: A_p = perforation area, square inches

V = volume cubic feet

Δt = draw down time in hours

ΔH = maximum head in feet

$$A_p = \frac{0.83 \text{ acre} - \text{feet} \times 43560 \frac{\text{ft}^2}{\text{acre}}}{120.3 \times 24 \text{ hr} \sqrt{2.39 \text{ feet}}} = 8.10 \text{ in}^2$$

The orifice area required is 8.10 in² and ten one-inch diameter holes could be used.

- 7 Calculate the vegetative bench area for planting of wetland vegetation. For this example 20 percent of the pool area (main pool plus forebay area) will be planted with wetland vegetation.

$$\text{Planting area } 0.28 \text{ acre} \times 43560 \frac{\text{ft}^2}{\text{acre}} \times 0.2 = 2440 \text{ ft}^2$$

Dry Detention Basins

BMP HC01.40 Dry Detention Basins

Purpose and Definition

Dry detention basins temporarily detain a portion of runoff for a specified length of time and release the storm water slowly. These basins are dry except for a period ranging from hours to several days following the storm event. Sedimentation is the primary pollutant removal mechanism in dry detention basins, allowing particulate and suspended solids to settle out of the water, thereby removing pollutants. The two most common types of dry detention basins are conventional and extended detention basins, depending on the design of the outlet structure that controls the release of storm water. Extended detention basins drain more slowly than conventional detention basins.

Application and Limitations

Dry detention basins are suitable BMPs where the expected concentrations of soluble pollutants from the area are low. Overall pollutant removal in dry detention basins is low to moderate. Dry detention basins can be used in conjunction with other BMPs.

Design Criteria

Several design factors determine the effectiveness of dry detention basins. *Table 1.6* summarizes the design parameter for dry detention basin design. The design of dry detention basins is similar to wet ponds with the exclusion of the permanent pool and aquatic shelf areas. These factors include water quality storage volume, hydraulic residence time, pond geometry, and outlet design. The basin dimensions and basin outlet structure should be designed to detain the design storm water runoff for an average detention time of 24 hours. The desired time may be achieved by using the full basin drain time of at least 48 hours, with no more than 50 percent of the water quality volume draining in the first 24 hours. *Figure 4 and 4-A* show examples of the layout and cross-sections of dry detention basins pond.

Sizing Procedure

- Determine the drainage area (A) that contributes runoff to the basin.
- Determine the water quality treatment volume (V_{wq}), which is 0.5 inch of runoff from the drainage area.
- Design the pond layout to achieve the length to width ratio of at least 3L:1W. The pond layout should maximize the flow path between the inlet and the outlet, minimize short-circuiting, and avoid dead storage area.

- Select a side slope based on the site condition. A side slope of 3H:1V or flatter is required for earthen basins.
- Prepare a pond grading plan (establish contours) and capacity-elevation table of the pond.
- Size an outlet to attain an average hydraulic detention time of 24 hours. This may be achieved by using the full basin drain time of at least 48 hours, with no more than 50 percent of the water quality volume draining in the first 24 hours.
- Specify overflow device such as emergency spillway and overflow elevation.
- Specify floatables control or trash trap devices.

Maintenance

Maintenance is the primary important factor if water quality dry detention basins are to continue to function as originally designed. Several studies conducted in the other parts of the USA have evaluated the pollutant removal performance of dry detention basins. The majority of the problems that affect the performance of these basins are associated with maintenance. Many dry basins have partially failed or are not meeting their design performance due to inlet or outlet clogging. Some of major performance-related problems encountered include excessive sediment or debris buildup, inappropriate ponding of water that resulted in uncontrolled vegetative growth, and clogging of the outflow structure.

A specific maintenance plan should be prepared outlining the schedule and scope of maintenance operation. This plan should be included in the Storm Water Quality Management Plan and submitted to the applicable agency. The maintenance plan should include at a minimum:

- Inspection frequency, removal of floating debris and accumulated petroleum products.
- Inspection and maintenance of outlet structures.
- Removal frequency and method of sediment disposal.
- Vegetation control and mowing.

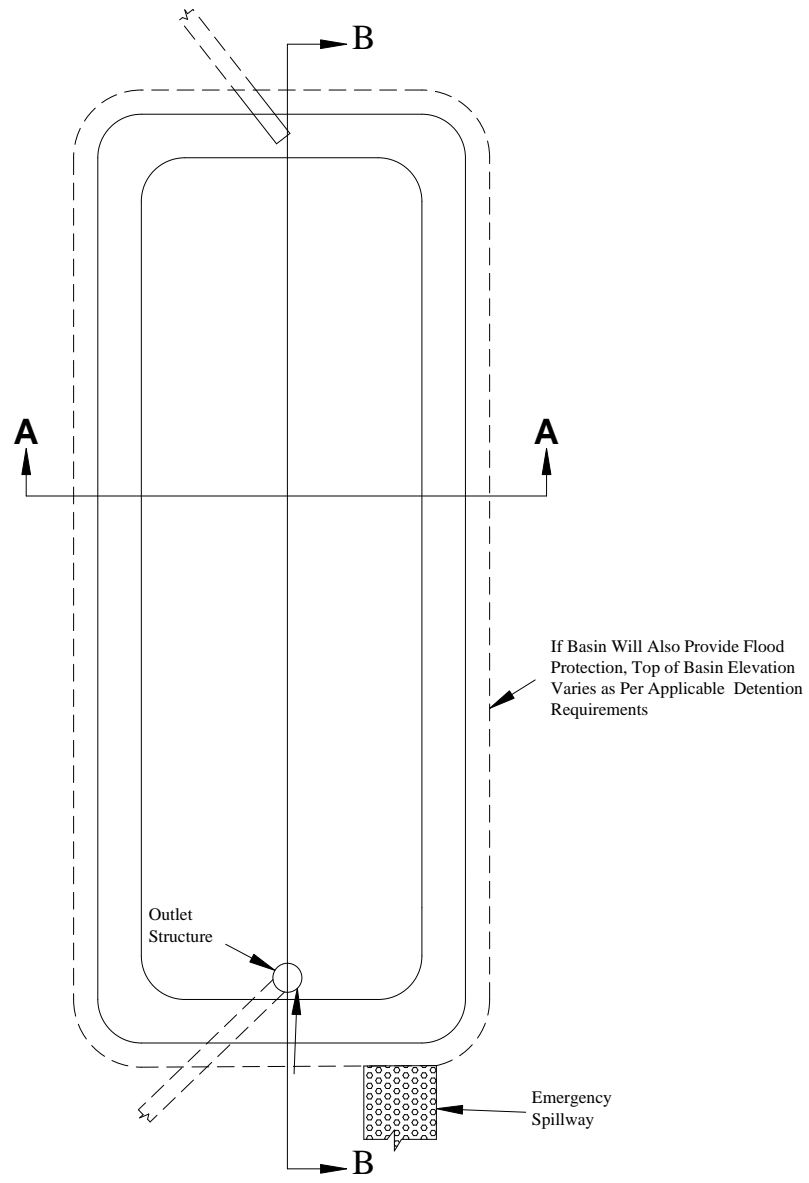
Table 1.6: Sizing Criteria for Dry Detention Basins

Design Parameters	Dry Detention Basin¹
Water quality treatment volume	0.5 inch of runoff from the drainage area
Permanent pool volume	NA
Permanent pool depth	NA
Pond geometry or length (L) to width (W) ratio ²	Length to width ratio of 3L:1W or more; avoid dead storage areas and minimize short-circuiting
Inlet location	Inlet shall be located 1 foot above the bottom of the basin
Side slope	3H:1V or flatter for earthen and no minimum for concrete
Hydraulic resident time	24 to 48 hours ³
Shallow water vegetative shelf	NA
Pond configurations (stages)	NA
Distance between inlet and outlet	Placed to maximize flow path and without causing short-circuiting
Outlet	Design to meet hydraulic resident time

¹Easement or restricted reserve dedication must contain wording that references the file number (permit number) and the public entity that holds the plan. The plan must include the maintenance schedule and frequency.

²All inlets and outlet that convey storm water runoff should be placed to maximize the flow path inside the basin.

³An average detention time of 24 hours is desired and may be achieved by using the full basin drain time of at least 48 hours, with no more than 50 percent of the water quality volume draining in the first 24 hours



PLAN
NTS

BMP HC01.40 - DRY DETENTION BASIN

Figure 4: Dry Detention Basin Example Design Layout

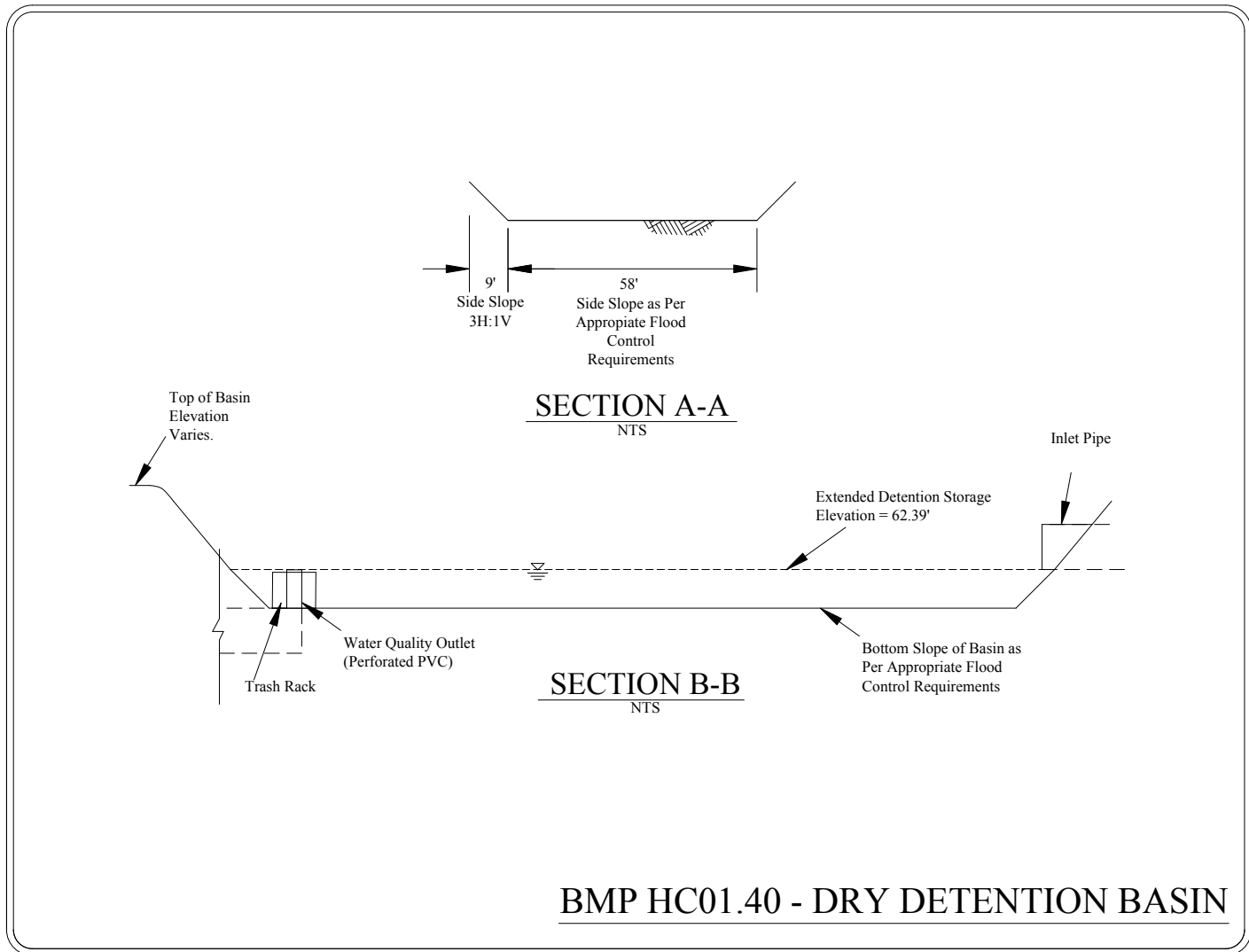


Figure 4-A: Dry Detention Basin Cross-Sections

Sample Calculation for Sizing Dry Detention Basin

Design Steps

- 1 Determine the drainage area that contributes storm water runoff. For this example a 20-acre site is selected and all of the area drains into the basin.
- 2 Compute the water quality treatment volume. The water quality treatment volume is 0.5" of runoff from the drainage area, which is 0.83 acre-feet.

$$V_{wq} = 0.5 \text{ in} \times \frac{1 \text{ ft}}{12 \text{ in}} \times 20 \text{ acres} = 0.83 \text{ acre - feet}$$

- 3 Design the basin layout with approximate length to width ratio of at least 3:1. The basin depth was set at 3 feet. The bottom width of the basin was 58 and the bottom length of the basin was 174 with the side slopes of 3:1.
- 4 Calculate the orifice area required to drain 50 percent of the water quality volume within 24-hours. Using the following equation from the Guidance Manual Page 4-38 the orifice area required would be:

$$A_p = \frac{V_{wq}}{120.3 \times \Delta t \sqrt{\Delta H}}$$

Where: A_p = perforation area, square inches

V = volume cubic feet

Δt = draw down time in hours

ΔH = maximum head in feet

$$A_p = \frac{0.5 \times 0.83 \text{ acre - feet} \times 43560 \frac{\text{ft}^2}{\text{acre}}}{120.3 \times 24 \text{ hr} \sqrt{3 \text{ feet}}} = 3.6 \text{ in}^2$$

The required orifice area would be 3.6 in² and eighteen half-inch diameter holes or equivalent could be used.

Constructed Wetlands for Storm Water Treatment

BMP HC01.50 Storm Water Treatment Wetlands

Purpose and Definition

Storm water treatment wetlands are constructed shallow ponds designed often based on the ecological function of natural wetlands. Natural wetlands are more or less self-maintaining systems; whereas, constructed wetlands for storm water treatment purposes require active management.

Wetlands are constructed in development and redevelopment activity for two main purposes. The first purpose is to mitigate lost, impacted or filled wetlands due to development or construction activity, and the second purpose is to treat storm water runoff (storm water treatment wetlands).

Newly constructed wetlands should be evaluated for exemption listed in 40 CFR 122.2 that provides an exemption to classification as “Waters of the U.S.” for treatment pond systems or lagoons designed to meet the requirements of the Clean Water Act. However, if a constructed wetland is exempted by being defined as a treatment facility, it cannot be used for wetlands mitigation for losses due to construction. Modification of an existing wetland area to serve for storm water treatment function is potentially subject to 404 permitting. The need for section 404 permits should be evaluated on a case-by-case basis.

Application and Limitations

Wetlands have shallower depths than wet ponds and generally requires more surface area to treat an equal amount of storm water runoff from the same size drainage area. Since water depths are shallower than wet ponds, water loss by evaporation is an important concern. Careful planning and water budget analysis is needed to be sure sufficient water will be retained to sustain good wetland plant growth. The most important pollutant removal processes in wetlands treatment systems are the purely physical processes of sedimentation via reduced velocities and filtration by wetland vegetation. Intimately linked with the sediment biota, the wetland vegetation serves as a major storage vector for carbon and nutrients, as an energy source for sediment microbial metabolism, and as a gas exchange vector between sediments and air. Thus, it is important to design for a substantial native emergent vegetative component.

Design Criteria

Wetlands design is site-specific but general design consideration includes a sediment forebay, maximized hydraulic retention time, elimination of dead zone and hydraulic short-circuiting, and selection and establishment of native wetland vegetation. *Table 1.7* summaries

the design parameter for storm water treatment wetland design. The sediment forebay should be provided for initial sediment deposition and reduction of storm water inflow velocities. It is very important to drop the initial suspended sediment load and lower the inflow water velocity to maintain system longevity and proper functionality of the wetland system. Most of the design elements discussed in the wet pond section are applicable to wetlands. The exceptions are depth and distribution of aquatic vegetation. These two parameters are discussed below.

The wetland area should consist of various depths and the following distribution of depths in the wetland cell could be used as a guide.

- 50 percent of the area should have 0.5-foot depth. This is the outer most section of the wetland area closer to the berm of the basin.
- 15 percent of the area should have 0.5 to 2-foot depth. This is the next inner section of the wetland area.
- 15 percent of the area should have 3 to 4-foot depth. This is the most inner section of the wetland area and mostly open water section.
- 20 percent of the area should have greater than 3-foot depth with maximum of 6-foot depth. This is the forebay or the pre-treatment section of the wetland.

- Other design considerations should include flow bypass for higher frequency storms.
- A soil study and geotechnical analysis should be conducted, and soil through the wetland area should have an infiltration rate low enough to maintain a permanent pool.
- Careful selection of diversified wetland plant species is one of the most important design aspects to avoid takeover of wetlands system by invasive aquatic nuisance plants.
- *Table 1.5* summarizes the criteria for the design parameters for storm water treatment wetlands.

Maintenance

Maintenance is the most important factor if storm water treatment wetlands are to continue to function as originally designed. A specific maintenance plan should be prepared outlining the schedule and scope of maintenance operation. This plan should be included in the Storm Water Quality Management Plan and submitted to the applicable agency. The maintenance plan should include at a minimum:

- Inspection frequency, removal of floating debris and accumulated petroleum products.
- Inspection and maintenance of outlet structures.
- Removal frequency and method of sediment disposal.

- Maintenance and management of the aquatic vegetation and aesthetic appearance of the site.

Table 1.7: Sizing Criteria for Storm Water Treatment Wetlands

Design Parameters	Wetlands¹
Water quality treatment volume	0.5 inch of runoff from the drainage area
Permanent pool volume	Same as water quality treatment volume
Depth of sediment forebay (Pre-treatment)	4 feet minimum and 6 feet maximum
Volume of pre-settling basin or forebay ²	20 % of the permanent pool volume
Pond geometry or length (L) to width (W) ratio ³	Length to width ratio of 3L:1W or more; layout the pond to avoid dead storage areas and minimize short-circuiting
Side slope	3H:1V or flatter
Surface-area-to-pool-depth relationship	50% of the area, 0.5 foot deep 15% of the area, 0.5 to 2 foot deep 15% of the area, 3 to 4 feet deep 20% of the area, greater than 3 feet deep with maximum of 6 feet deep (forebay section)
Wetland Vegetation	Diverse mixture of floating, emergent and submergent plants; consult a wetland specialist for a specific plant species suitable to the project site
Distance between inlet and outlet	Placed to maximize flow path and without causing short-circuiting.
Outlet	Size to meet extended detention storage

¹Easement or restricted reserve dedication must contain wording that references the file number (permit number) and the public entity that holds the plan. The plan must include the maintenance schedule and frequency.

²All inlets that convey storm water runoff should enter first the forebay or pre-treatment basin.

³The flowpath length from inlet to outlet should be measured along the deepest section and the width can be found as (average top width + average bottom width)/2.

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APPENDIX (Design Check List)

Vegetated Filter Strips

Design Parameter	Minimum	Maximum	Value	Units
Drainage Area Serviced		10 ¹		Acres
Width of Buffer Strip	20	45		ft
Overland Travel Distance (to start of Vegetative Buffer Strip)		150		ft
Maximum Flow Velocity		1		ft/s
Easement or Restricted Reserve ²				Acres
Slope	0.1%	10%		%
Flow Spreader				
Sampling Location (Treated)				
Type of Vegetation				
Height of Vegetation				ft or inches
Collection System				
Type of System				
Design Frequency				
Maximum Flow				
Maximum Depth				
Maintenance Considerations				
Frequency of Owner/Operator Self Inspection (per half inch rainfall event)	every			
Frequency of Owner/Operator Self Inspection	1	2		weeks
Clear Out Criteria				
Permit Renewal Frequency	6	12		months
Reporting Frequency, Certification Frequency, Permit Renewal, Operation Permit				

¹ In developments draining more than 10 acres, filter strips could be used as a supplement with other best management practices.

² The easement or plat dedication must contain wording which references the file number (or permit number) and the public entity that holds the plan. The plan will include the accepted maintenance plan.

Grass Swales

Design Parameter	Minimum	Maximum	Value	Units
Land Area Serviced		10 ¹		Acres
Length of Travel	50			ft
Maximum Flow Velocity		1.5		ft/s
Design Depth		1/2 grass height or 3 inch, whichever is less		ft
Type of Grass	Specify			
Roughness Coefficient	0.24	0.40		
Longitudinal Slope	0.1	2%		%
Side Slope	3H:1V			
Bottom Width				ft
Easement or Restricted Reserve ²				Acres
Design Equation	Specify			
Discharge Conditions	Specify			
Sampling Location (Treated)	Specify			
Conveyance of the less frequent storm such as a 2-year must be done in a different location or by a different method. For properties larger than 10-acres, this system can be used in conjunction with one of the detention ponds				
Overflow Considerations				
Overflow Elevation	Specify			ft
Overflow Device	Specify			
Design Equation	Specify			
Maintenance Considerations				
Frequency of Owner/Operator Self Inspection (per half inch rainfall event)	every			
Frequency of Owner/Operator Self Inspection	1	2		weeks
Permit Renewal Frequency	6	12		months
Reporting Frequency, Certification Frequency, Permit Renewal, Operation Permit				

¹ In developments draining more than 10 acres, filter strips could be used as a supplement with other best management practices.

² The easement or plat dedication must contain wording which references the file number (or permit number) and the public entity that holds the plan. The plan will include the accepted maintenance plan.

Dry Detention Basins

Design Parameter	Minimum	Maximum	Value	Units
Drainage Area Served				Acres
Easement or Restricted Reserve ²				Acres
Design Depth				ft
Design Volume	0.5			Inch per acre
Side Slope	earthen channels => preferred)	3H:1V		H:V ft/ft
	(concrete channels)	n/a		
Bottom Slope	earthen channels => preferred)	0.1		%
Design Water Surface Elevation				ft
Average Detention Time	24			Hours
Design Flow Rate				ft ³ /s
Outlet Type				
Design Equation				
Sampling Location (s) (Pre-treatment and Treated)				
Dual Use Design Considerations (Optional)				
Design Storm (2-year, 100-year)				
Detention Volume				
Water Surface Elevation				ft
Side Slope				ft H/ft V
Outlet Size and Type				ft
Design Equation				
Allowable and Design Flow Rate				ft ³ /s
Overflow Considerations				
Overflow Elevation				ft
Overflow Device				
Design Equation				
Floatable Trapping Mechanism				
Maintenance Considerations				
Settling Basin Clean Out Criteria (% volume lost in forebay, if included in the design)		50%		
Frequency of Owner/Operator Self Inspection (per half inch rainfall event)	every			
Frequency of Owner/Operator Self Inspection	1	2		weeks
Permit Renewal Frequency	6	12		months
Reporting Frequency, Certification Frequency, Permit Renewal, Operation Permit				

¹ In developments draining more than 10 acres, filter strips could be used as a supplement with other best management practices.

² The easement or plat dedication must contain wording which references the file number (or permit number) and the public entity that holds the plan. The plan will include the accepted maintenance plan.

Wet Ponds

Design Parameter	Minimum	Maximum	Value	Units
Main Pool Depth at deepest point	4	6		ft
Pond Area (includes berms, etc.)				ft ² or acres
Side Slope	3			ft H / ft V
Bench Elevation Above Permanent Water Surface Elevation				ft
Drainage Area Serviced				Acres
Easement or Restricted Reserve*	1			Acres
Length to Width Ratio	3			
Forebay Volume %	20%			
Design Volume	0.5			Inches per acre
Side Slope	earthen	3		H:V ft/ft
	concrete	n/a		
Design Water Surface Elevation				ft
Outlet Type				
Design Equation				
Sampling Location (s) (Pre-treatment and Treatment)				
Vegetation Types				
Vegetated Shelf Area	20%			
Dual Use Design Considerations (Optional)				
Design Storm (2-year, 100-year)				
Detention Volume				acre-ft
Water Surface Elevation				ft
Side Slope				ft H/ft V
Outlet Size and Type				ft
Design Equation				
Design Flow Rate				ft ³ /s
Overflow Considerations				
Overflow Elevation				ft
Overflow Path				
Overflow Device				
Design Equation				
Floatable Trapping Mechanism				
Maintenance Considerations				
Settling Basin Clean Out Criteria (% volume lost in forebay)		50%		
Frequency of Owner/Operator Self Inspection (per half inch rainfall event)	every			
Frequency of Owner/Operator Self Inspection	1	2		weeks
Permit Renewal Frequency	6	12		months
Reporting Frequency, Certification Frequency, Permit Renewal, Operation Permit				

APPENDIX B

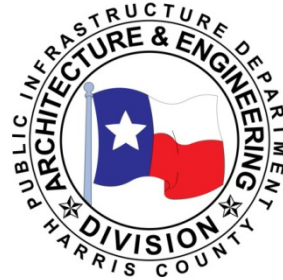
Type 1 Facility Monitoring Thresholds

Required of Type 1 Facilities	
Parameter	Value
Total Oil and Grease	15 mg/l
Chemical Oxygen Demand (COD)	120 mg/l
pH	6-9 Standard Units
Biochemical Oxygen Demand (BOD)	30 mg/l
Total Suspended Solids (TSS)	100 mg/l
Total Phosphorus	2 mg/l
Nitrate plus Nitrite Nitrogen	0.68 mg/l
Total Kjeldahl Nitrogen (TKN)	15 mg/l
Total Organic Carbon	75 mg/l
NH ₃	15 mg/l
Temp	100 degrees F

APPENDIX C

Harris County Low Impact Development & Green Infrastructure Design Criteria for Storm Water Management

Harris County Low Impact Development & Green Infrastructure Design Criteria for Storm Water Management



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Adopted by Harris County Commissioners Court

Ed Emmett
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Adopted April 2011

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PART I

Background

This document is intended to provide a set of interim guidelines for the use of Low Impact Development (LID) and Green Infrastructure (GI) techniques. Over the last couple of years there has been an increased public interest in the regulatory adoption of LID and GI techniques, as a potential land development option to address drainage and storm water quality requirements. The Environmental Protection Agency has also required the adoption of such "region-appropriate practices" by November 1, 2011, as a part of the Harris County Public Infrastructure Department Architecture & Engineering Division (HCPID-AED) and Harris County Flood Control District (HCFCD) Storm Water Management Programs. This requirement is specifically located in the Bacteria Reduction Plan found in Section 12 of the Storm Water Management Program." (HCFCD, 2010 and HCPID-AED, 2010).

It is anticipated that these criteria will be in an interim form for at least 3 years after the date of adoption. During this interim period, design techniques will be reviewed and monitored for implementation success to determine how these interim criteria should be modified in the future. If at any time during this interim period HCPID-AED & HCFCD determine that a modification to the criteria is necessary, updates to this document will be issued. When such updates are issued they will affect all developments that have not yet had a pre-project meeting (See Section 2.2).

These criteria do not require a "conventional development" project to follow these LID requirements, nor do they intend for every project to be a LID project. However, these requirements shall apply to any new development or re-development project choosing to incorporate LID practices for the purpose of satisfying current HCPID-AED and/or HCFCD requirements for detention, infrastructure, stormwater quality, or other applicable requirements. Furthermore, it is intended that these guidelines should assist in the facilitation by Texas Commission on Environmental Quality (TCEQ) of Municipal Utility District (MUD) reimbursements for LID and GI elements.

Illustrations have been included in this document to aid in the understanding of the criteria. These illustrations are intended to provide visual reference to the concepts addressed in the criteria; however, they are not construction details and should not be used as such. The Integrated Management Practices used under this document are to be designed to meet the criteria as applicable to the development intended.

Final approval of the use of any LID techniques shall not include a maintenance responsibility for HCPID-AED, HCFCD, or any Harris County Precinct, unless specifically agreed to otherwise.

1 Introduction to Low Impact Development

Low Impact Development (LID) is a comprehensive land planning and engineering design approach with the goal of maintaining, as the minimum, the pre-development hydrologic regime in a watershed without solely using conventional development and detention basin techniques to satisfy drainage and flood mitigation requirements.

The term Green Infrastructure (GI) is synonymous with LID. Both terms describe an approach to infrastructure management that is cost-effective, sustainable, and environmentally friendly. GI, like LID management approaches and technologies, infiltrate, evapotranspire, capture and/or reuse storm water to maintain or restore natural hydrology. Integrated Management Practices (IMPs) are LID based practices that reduce stormwater runoff volume and pollutant loading from developed sites. IMPs function by slowing runoff, promoting infiltration, and utilizing evapotranspiration through plantings.

Principles of LID

- Conserve natural resources that provide valuable natural functions associated with controlling and filtering storm water.
- Minimize & disconnect impervious surfaces.
- Direct runoff to natural and landscaped areas conducive to infiltration.
- Use distributed small-scale controls or Integrated Management Practices (IMPs) to mimic the site's pre-project hydrology.
- Storm water education leads to pollution prevention.

1.1 LID Site Planning Concepts

Hydrologic goals and objectives should be incorporated into the site planning process as early as possible. The goal of LID site planning is to allow for full development of the property while maintaining pre-development hydrologic functions as opposed to solely comparing outfall rates. A few fundamental concepts that define the essence of low impact development technology must be integrated into the site planning process to achieve a successful and workable plan. These concepts are so simple that they tend to be overlooked, but their importance cannot be overemphasized. The steps to achieve LID include first minimizing the hydrologic impacts created by the site development through site design, and then providing controls to mitigate or restore the unavoidable disturbances to the hydrologic regime. These fundamental concepts are defined in the following sections:

- Using Hydrology as the Integrating Framework
- Controlling Storm Water at the Source
- Creating Multi-Functional Landscape and Infrastructure

1.1.1 Using Hydrology as the Integrating Framework

In LID technology, the traditional approach to site drainage is reversed to mimic the natural drainage functions. Instead of rapidly and efficiently draining the site, LID relies on various planning tools and control practices to preserve the natural hydrologic functions of the site. The application of LID techniques results in the creation of a hydrologically functional landscape, the use of distributed micromanagement practices, impact minimization, and reduced effective imperviousness. The process allows for maintenance of infiltration capacity, storage, and longer time of concentration.

Integration of hydrology into the site planning process begins by identifying and preserving sensitive areas that affect the hydrology, including streams and their buffers, floodplains, wetlands, steep slopes, high and low permeability soils, and woodland conservation zones. This process defines a development envelope, with respect to hydrology, which is the first step to minimizing hydrologic impacts. This development envelope may have the least hydrologic impact on the site while retaining important natural hydrologic features.

- | |
|--|
| <p style="text-align: center;">Integrating Hydrology</p> <ol style="list-style-type: none">1. Identify sensitive areas that affect hydrology2. Define the Development Envelope3. Minimize total impervious area4. Disconnect Impervious surfaces5. Control and breakup impervious areas with IMPs |
|--|

1.1.2 Controlling Storm Water at the Source

LID IMPs implemented on small drainage areas allow for a distributed control of storm water throughout the entire site. This process offers significant opportunities for maintaining the site's key hydrologic functions including infiltration/biofiltration, depression storage, and interception, as well as an increase in the time of concentration. The key to restoring the predevelopment hydrologic functions is to minimize and then mitigate the hydrologic impacts of land use activities closer to the source of generation. Natural hydrologic functions such as interception, depression storage, and infiltration/biofiltration are evenly distributed throughout an undeveloped site.

1.1.3 Creating Multi-Functional Landscape and Infrastructure

LID offers an innovative alternative approach to urban storm water management that uniformly or strategically integrates storm water controls into multifunctional landscape features where runoff can be micromanaged and controlled at the sources. LID may allow a variety of urban landscapes or infrastructure feature (roof, streets, parking, sidewalks, collection/conveyance systems and green space) to be designed to be multifunctional, incorporating detention, retention, filtration, or runoff use, where feasible.

PART II

2 Approval Process & LID-Based Project Criteria

A LID-based project is one which takes a comprehensive land planning and engineering design approach with the goal of maintaining, as the minimum, the pre-development hydrologic regime in a watershed without solely using conventional development and detention basin techniques. These projects will typically be characterized by the use of distributed IMPs, as described in Appendix A, rather than centralized pipe and detention basin approaches to meet these goals.

The LID analysis and design approach focuses on the following hydrologic analysis and design components:

- **Time of Concentration (Tc):** Maintaining the pre-development Tc by minimizing the increase of the peak runoff rate after development by lengthening and flattening flow paths and reducing the length of the highly efficient conveyance systems.
- **Retention:** The storage of stormwater for an indefinite period of time. A retention feature does not have an outlet structure, but relies on infiltration, often supplemented by amended soils to improve the infiltration characteristics.
- **Detention:** The temporary storage of stormwater. A detention feature temporarily detains stormwater with an outlet that restricts the outflow to a pre-project development rate. For LID projects, the goal is to drain within 72 hours, unless pre-existing conditions are shown to take longer.
- **Change in Impervious Cover:** Minimizing changes in impervious areas and preserving more natural areas to reduce the storage requirements to maintain the predevelopment runoff volume.
- **Disconnection:** Distributing concentrated flow through landscape in a manner intended to promote slower velocities and infiltration.

2.1 Acceptable LID Practices

Table 1 below describes which LID IMPs will be acceptable for use in satisfying storm water quality and detention requirements.

Table 1. Acceptable LID IMPs for Storm Water Management and Mitigation Credit

IMP	Storm Water Quality	Detention	Time of Concentration
Bioretention & Engineered Soil	X	X	X
Vegetated Swale	X	X	X
Vegetated filter strip	X		X
Permeable Pavement	X	X* (1)	X
Tree Box Filter	X	X	X
Storm Water Planter	X	X	X

Green Roof	X		X
Disconnection	X		X
Soil Amendment	X		X
Rainwater Harvesting	X* (2)	X* (3)	

*(1) Voids within the permeable pavement itself can not be counted for detention, see section 3.6.1.

*(2) Acceptable for Storm Water Quality if re-used for irrigation or other non-potable uses.

*(3) Various LID practices will be considered, so long as sufficient volume reductions and the design approach are proven. Applies only to commercial sites and non-single family residential structures in limited circumstances, see section 3.4.1.

2.2 Pre -Project Meeting Requirements

Any person proposing to utilize LID IMPs shall have a pre-project meeting with HCPID-AED & HCFCD. The Harris County Permit Office is responsible for coordination of the meeting with HCPID-AED and HCFCD personnel.

Table 2. Pre-Project Review Meetings

<p>Mandatory Pre-Project Meeting</p>	<p>Pre-project meetings with HCPID-AED and HCFCD will be mandatory for projects utilizing LID. The pre-project meeting is intended to ultimately expedite the review process. Consultants should prepare for these meetings with:</p> <ul style="list-style-type: none"> • A list of proposed LID practices, with schematics and assumptions. • Exhibits of the project area with topographic information. • References in this Design Guide and/or the PCPM which relate to the project. <p>In addition, this meeting will provide an opportunity for discussion of proposed hydrologic modeling methods. Once the conditions of the submittal have been defined at the pre-project meeting, future submittals will not be considered as variances and will advance through the approval system in the normal manner.</p>
<p>Agency Response to Pre-Project Meeting</p>	<p>Meeting minutes shall be provided by the development engineer and submitted for approval by HCPID-AED & HCFCD after the pre-project meeting that describes the LID processes to be used and the method of design of the LID systems. Any approvals issued will be valid for 2yrs and will not be transferable to others.</p>

2.3 Detention and Hydrograph Requirements

Table 3: Detention and Hydrograph Requirements

Subject	HCFCF Requirements	HCPID-AED Requirements
Detention Criteria	The minimum detention rate for gravity drained detention basin systems is 0.55 ac-ft per acre. Any reductions to this rate will be based on approved hydraulic methodology based on low impact design techniques such as reduced impervious cover, increased time of concentration, etc. However, the minimum detention rate with approved low impact techniques is 0.35 ac-ft per acre. Acceptable low impact techniques and analysis methodology must be discussed and agreed upon at a pre-project meeting with HCFCF.	Minimum detention rate of 0.55 ac-ft per acre for outfalls into a Harris County maintained roadside ditch, and 50% of the required detention rate determined using the Harris County Infrastructure Regulations Section 6.03.2 for outfalls into a Harris County maintained storm sewer. Any reductions to this rate will be based on approved hydraulic methodology based on low impact design techniques such as reduced impervious cover, increased time of concentration, etc. Acceptable low impact techniques and analysis methodology must be discussed and agreed upon at a pre-project meeting with HCPID-AED.
Monitoring	HCPID-AED and/or HCFCF may be allowed to monitor, test, and/or inspect any LID IMP, and may choose to coordinate with the owner for the design elements the agencies might need for future monitoring by the agencies.	
Area Eligible for Low Impact Development	The portion of the drainage area within the project limits covered by an agreement for maintenance, repair, and rehabilitation of the facilities. LID Practices must be pre-approved at the mandatory pre-project meeting.	
Peak Flow	The LID design must show that the post-project condition has an equal or lower peak flow than the pre-project condition peak flow.	
Hydrologic Calculations and Acceptable Modeling Techniques	TBD at the required pre-project meeting. Techniques will be driven by project size (see section 2.3.1), although multiple methods may be accepted.	
Location Relative to Flood Risk Zone	Developments in a regulatory floodplain will abide by current floodplain regulations.	
Eligible LID Practices	<p>Various LID practices will be considered, so long as sufficient volume reductions and the design approach are proven. In general, LID practices which can be shown to result in the following benefits will be considered:</p> <ul style="list-style-type: none"> • Reduced impervious cover • Disconnected impervious cover • Increased time of concentration, including cumulatively over the entire development site. • Increased losses in effective rainfall through storage, interception, etc. • Dispersed storage • A factor of safety of 1.25 for engineered soil void space calculations is required. 	

2.3.1 Threshold Acreages and Analysis Methodologies Requirements

The following design approaches must be considered for the respective size of the overall development. The standard of no adverse impact between pre-project and post-project will be held across all threshold acreages. Additionally, pre and post-project analyses must follow identical methodologies across all threshold acreages.

Table 4. Threshold Acreages and Analysis Methodology Requirements

Site Acreage	HCFCF Requirements*	HCPID-AED Requirements
Site ≤ 10 Acres	<ul style="list-style-type: none"> • No adverse impact for 2-Year, 10-Year, and 100-Year events. • Peak flow: Rational Method • NRCS TR-55 (Chapter 3) presents an acceptable method for calculating time of concentration (t_c). Other methods may be presented at the pre-project meeting. • End-of-pipe analysis: Compare Q_{exist} v. Q_{prop}, and meet minimum detention rate of 0.55 ac-ft per acre if an analysis is not performed. A comparison of pre and post-project t_c is an alternative method of analysis under the Rational Method. 	<ul style="list-style-type: none"> • Same as HCFCF • End-of-pipe analysis: Compare $Q_{allocated}$ v. Q_{prop}, and meet minimum detention rate of 0.55 ac-ft per acre for outfalls into a Harris County maintained roadside ditch, and 50% of the required detention rate determined using the Harris County Infrastructure regulations section 6.03.2 for outfalls into a Harris County maintained storm sewer. A comparison of pre and post-project t_c is an alternative method of analysis under the Rational Method. $Q_{allocated}$ is to be determined by using Harris County Infrastructure Regulations sec 6.03.4
10 Acres < Site < 640 Acres	<ul style="list-style-type: none"> • No adverse impact for 2-Year, 10-Year, and 100-Year events. • Hydrologic Methodology (see PCPM for details). • Detailed routing may be required. • End-of-pipe analysis (see above). 	<ul style="list-style-type: none"> • Same as HCFCF
Site ≥ 640 Acres	<ul style="list-style-type: none"> • No adverse impact for 2-Year, 10-Year, and 100-Year events. • Hydrologic Methodology (see PCPM for details). • Requires detailed routing • Analysis at end-of-pipe and at critical point(s) downstream. 	<ul style="list-style-type: none"> • Same as HCFCF

* HCFCF Requirements listed in this document are supplemental to the criteria and procedures in the HCFCF 2010 Policy, Criteria, and Procedures Manual, they do not replace them.

2.4 Storm Water Quality Treatment

LID-based projects of one acre or larger, or those which are part of a larger plan of common development which exceed one acre, shall have a Storm Water Quality (SWQ) Permit and the accompanying Storm Water Quality Management Plan (SWQMP). The Maintenance Plan incorporated into the SWQMP must meet or

exceed the maintenance requirements indicated in these criteria for the LID practices utilized. Single-family residential projects of one acre or less in size are exempt from this requirement.

Table 5: Storm Water Quality Treatment Requirements

Site Acreage	Requirements
Site \geq 1 Acre	<ul style="list-style-type: none"> • Treatment of the first 1" of runoff • Storm Water Quality Permit required. • Storm Water Quality Management Plan (SWQMP) required.

3 LID IMP Design Criteria

3.1 Disconnection of Roof Runoff & Impervious Surfaces

Disconnection of impervious surfaces is encouraged to maximize the function of the LID practices. This method is used to increase time of concentration and promote infiltration, thereby helping to improve water quality. More detailed information can be found in Appendix A.

3.2 Vegetated Filter Strip

A vegetated Filter Strip is a band of dense vegetation, usually grass, planted between a pollution source (e.g., roadway, rooftop downspout, etc.) and a downstream receiving water body or conveyance. The filter strips function by slowing runoff, trapping sediment and pollutants, and in increasing the ability to infiltrate a portion of the runoff into the ground. More detailed information can be found in Appendix A.

3.2.1 Requirements

- The longest flow path to a filter strip, without the installation of energy dissipaters and/or flow spreaders, should not exceed 75 feet for impervious ground cover and 150 feet for pervious ground cover.

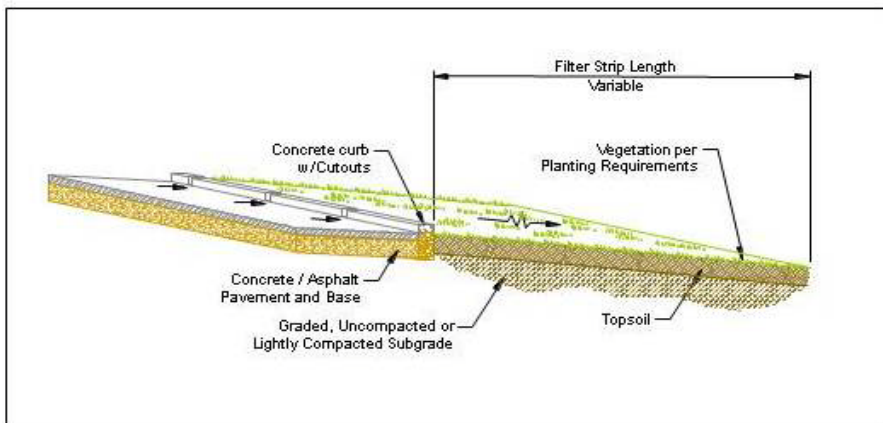


Figure 1. Vegetated Filter Strip (Perspective Cutaway View)

3.3 Vegetated Swale

Vegetated Swales are broad, shallow channels designed to convey and filter storm water runoff while slowing runoff and removing gross pollutants. They handle runoff from small drainage areas at low velocities.

3.3.1 Requirements

- The bottom and sides of the swale must be vegetated. Surface ponding in a vegetated swale must not exceed 24 hours, however a longer time frame may be considered to match existing conditions hydrograph.
- Public safety and integrity of adjacent structures must be evaluated when considering ponding depth and duration.
- See section 4.1.2 for swales used in Roadways.

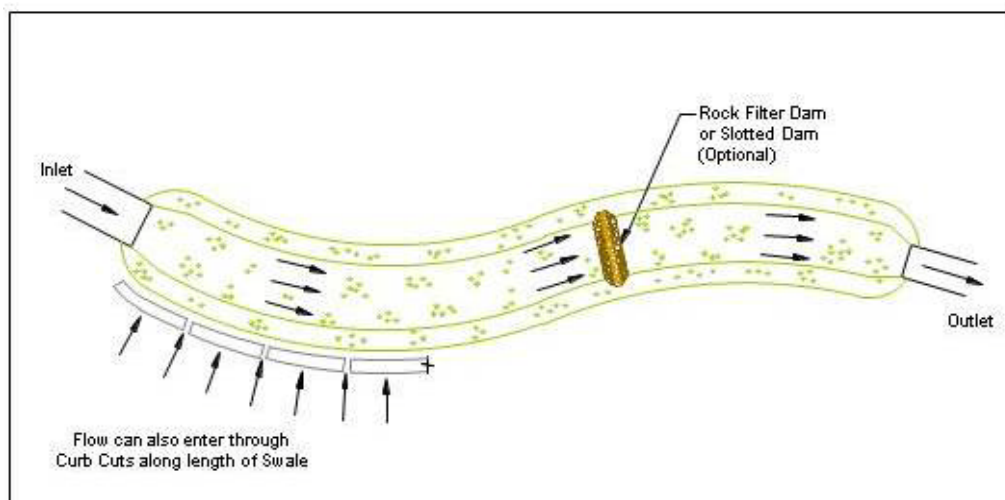


Figure 2. Vegetated Swale (Perspective Cutaway View)

3.4 Rainwater Harvesting

Rainwater harvesting systems, including cisterns, rain barrels, and underground storage systems are designed to capture roof runoff for reuse. Cisterns reduce the runoff volume only when the cistern is empty and may not reduce the peak flow rate for small, frequently occurring storms. These systems can help provide a means for water storage to serve irrigation purposes and may factor into a water conservation plan. More detailed information can be found in Appendix A.

3.4.1 Requirements

- Acceptable for water quality and detention on the commercial site or non-single family residential structures.
- Development of a water budget shall be conducted to show how volume is made available for detention.
- Storage capacity must be designed to assure capacity is available in multiple rain events.
- Not typically accepted for detention purposes.

3.5 Bioretention Systems

Bioretention is a water quality and water quantity control practice using the chemical, biological and physical properties of plants, microbes and soils for biofiltration and the removal of pollutants from storm water runoff. Bioretention Cells, or Rain Gardens, are vegetated depressions, filled with an engineered soil media which provides biofiltration for removal of pollutants, increases time of concentration, may provide detention and prevents long-term storm water surface ponding. More detailed information can be found in Appendix A.

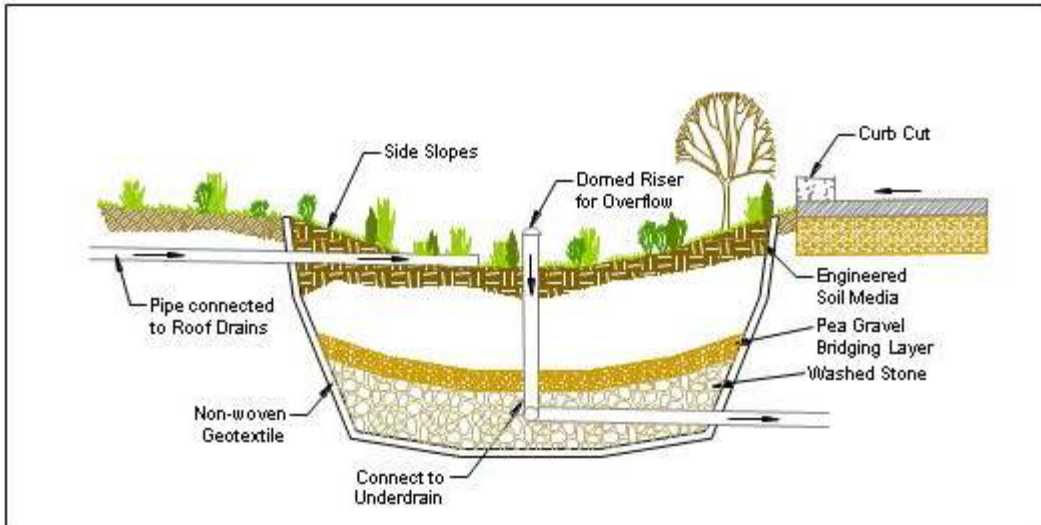


Figure 3. Bioretention Cell/Rain Garden (Section View)

Note: Soil media, type, size, and quantity to be determined in the individual designs.

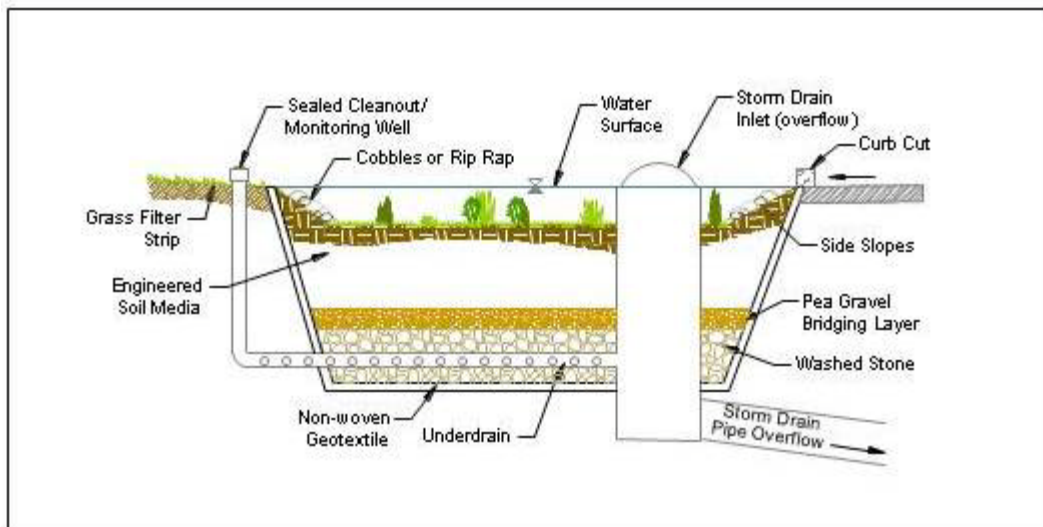


Figure 4. Bioswale (Section View)

Note: Soil media, type, size, and quantity to be determined in the individual designs.

3.5.1 Requirements

Table 6. Bioretention System Components

BIORETENTION SYSTEM COMPONENT	REQUIREMENT	PURPOSE OF COMPONENT
Geotextile Filter Fabric	required	Separate Engineered Soil Media from in situ soils. (Not to be used as separation layer between Engineered Soil Media and drainage aggregate surrounding underdrain.)
Engineered/Amended Soil Media	required	Provide high infiltration rates, safety factor of 2 for design infiltration rate and suitable substance for proposed vegetation. Provides water quality enhancement to intercepted runoff. Design infiltration rate based on size of drainage area, size of infiltration zone, underdrain inflow capacity, and treatment of the first 1" of runoff. A factor of safety of 2 should be applied in order to offset potential degradation of flow rate. See appendix B for testing requirements.
Vegetation	required	Provides water quality benefits, increased runoff storage and infiltration support as well as root absorption, erosion protection and evapotranspiration.
Bridging Aggregate	required	Aggregates used as 'bridging materials to create a separation layer between Engineered Soil Media and underdrain aggregate.
Aggregate	required	Surrounds the underdrain and provides increased volume/area capacity available to the storage component of the swale.
Underdrain	required*	Provides a secondary conveyance component to a standard bioretention swale design. May also incorporate added retention volume/storage for rainwater recycle. Underdrain must be sized to accommodate inflow and assuming 50% blockage of orifices by aggregate. *Required, unless in situ soils are proven viable for direct infiltration.
Observation/Cleanout Standpipe	required	Installed at both ends of the system and at all bends, and at 50' intervals, if run exceeds 100'. Made of min. 6" PVC pipe and capped.
Positive Overflow	required	Safely convey excessive runoff from extreme storm events. Grate must be sloped or otherwise designed to prevent clogging by mulch and debris.
Storage Chamber Products	not required	Provides the highest volume/area capacity available to the storage component of the bioretention swale.
Outfall Structure	required	Controls the rate of flow off the project site and maintains the extreme event discharge requirements.
Surface Ponding	required	Maximum surface ponding depth of 2ft for the 2yr event and 4ft for the 100yr event. Ponding duration not to exceed 24 hours. Ponding depth & duration shall be discussed at the pre-project meeting.

3.5.2 Sizing a Bioretention System

For a Bioretention System with an underdrain, the calculations for Water Quality Volume (Vwq) and Required Surface Area (Af) are as follows:

$$Vwq = (P / 12) * A$$

Where,

- Vwq = water quality volume in Cubic Feet
- P = depth of runoff to treat (1" under these guidelines)
- A = drainage area in Square Feet

$$k = (i * 24) / 24$$

Where,

- k = coefficient of permeability of engineered soil bed
- i = infiltration rate of engineered soil media in inches per hour

$$Af = Vwq * Df / [k * (H + Df) (Tf)]$$

Where,

- Af = required surface area of Engineered Soil Media in Square Feet
- Vwq = water quality volume in Cubic Feet
- Df = engineered soil media depth in Feet (typically 1.5 - 2.0)
- H = maximum ponding depth over Engineered Soil Media in Feet
- Tf = Drawdown time in Days

3.5.3 Engineered Soil Media

The infiltration rate of Engineered Soil Media in a bioretention facility must be designed to treat the first 1" of runoff volume from the drainage area it serves. In order to minimize maintenance needs and insure performance, the Design Infiltration Rate (inches per hour) must account for potential future degradation and therefore, must provide a minimum safety factor of 2.

For quality control purposes, the supplier of the Engineered Soil Media must provide a certificate which indicates the infiltration rate of the media on delivery to the project site. An in situ test must be conducted on site after engineered soil media is placed and settled to insure that the design infiltration rate is met or exceeded. This test shall be conducted using a field Infiltrometer as outlined in Appendix B.

The separation of the Engineered Soil Media and the aggregate surrounding the underdrain below it must be handled with care. Historically, geotextile fabrics (typically nonwoven) have been used as a separation layer; however, these are highly susceptible to clogging which renders the bioretention system inoperable. Fabric separation layers shall be avoided.

Instead, a thin layer (or two) of appropriately sized aggregates should be utilized as a "bridging" layer (sometimes called a "choker" course or "separator lens"). A layer of pea gravel will typically provide this

bridge. Essentially, this practice relies on the largest 15% of the Engineered Soil Media “bridging” with the smallest 15% of the underdrain aggregate particles. Commonly used in United States Golf Association (USGA) greens construction, this method is simple, highly effective and not susceptible to clogging (USGA, 2004).

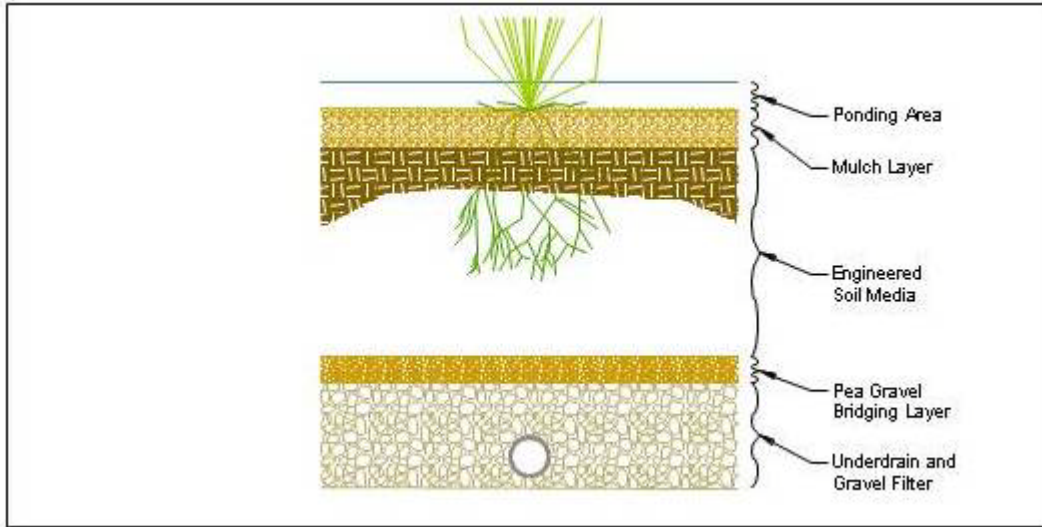


Figure 5. Bridging Engineered soil and underdrain system

3.5.4 Underdrain

Underdrain structures, including subsurface detention or storage structures which are used under Bioretention systems must have a total opening area which exceeds the expected flow capacity of the underdrain itself.

$$Q_{\text{perforations}} = C * A \sqrt{2gh} / B$$

Where,

- g = Acceleration due to gravity (32.2 ft/S²)
- A = total area of orifice (units??)
- h = maximum depth of water above the pipe (units??)
- C = orifice coefficient
- B = blockage factor (2)

This aggregate layer surrounding the underdrain should consist of washed aggregate ½”-1½” in diameter. Holes in underdrain pipe shall consist of the minimum required area calculated above with a minimum hole diameter of ¼”.

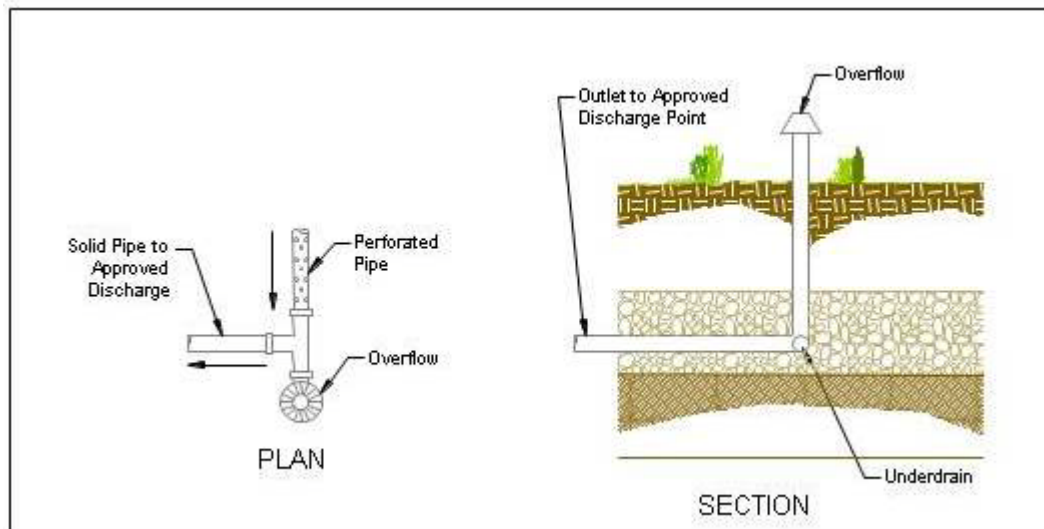


Figure 6. Underdrain (Plan & Section View)

3.5.5 Observation/Cleanout Standpipe

An observation/cleanout standpipe must be installed to the underdrain in every Bioretention Cell/Rain Garden or Bioswale. The standpipe will serve two primary functions: 1) it will indicate how quickly the bioretention IMP dewateres following a storm; and 2) it provides a maintenance port. The cleanout standpipe must be located at the upper end of the structure and be capped above the maximum ponding level elevation. It must consist of a rigid, non-perforated PVC pipe, 4 -6 inches in diameter. A cleanout must be installed at both ends of the system and at any bends.

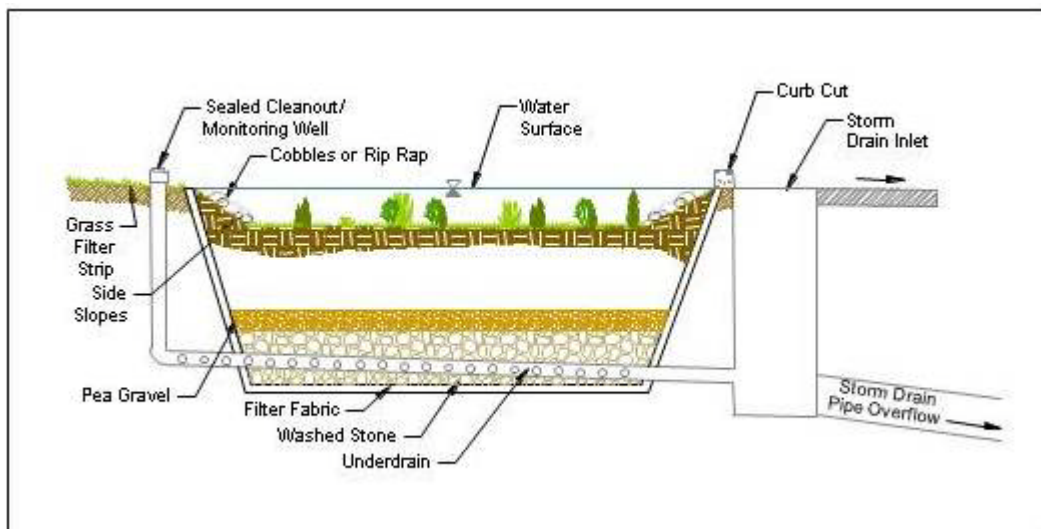


Figure 7. Observation/Cleanout Standpipe

If the Bioretention facility exceeds 100 feet in length; additional cleanouts must be installed in series every 50 feet. The top of the cleanout must be capped with a screw, or flange type cover to discourage vandalism and tampering.

3.5.6 Positive Overflow

Positive overflow options include:

- A domed riser may be installed to ensure positive, controlled overflow from the system. Once water ponds to a specified depth, it will begin to flow into the riser through a grate, which is typically domed to prevent clogging by mulch or debris.
- An inlet structure with sloped grate may also be installed to ensure positive, controlled overflow from the system. Once water ponds to a specified depth, it will begin to flow into the inlet. A sloped face will prevent clogging by mulch or debris.

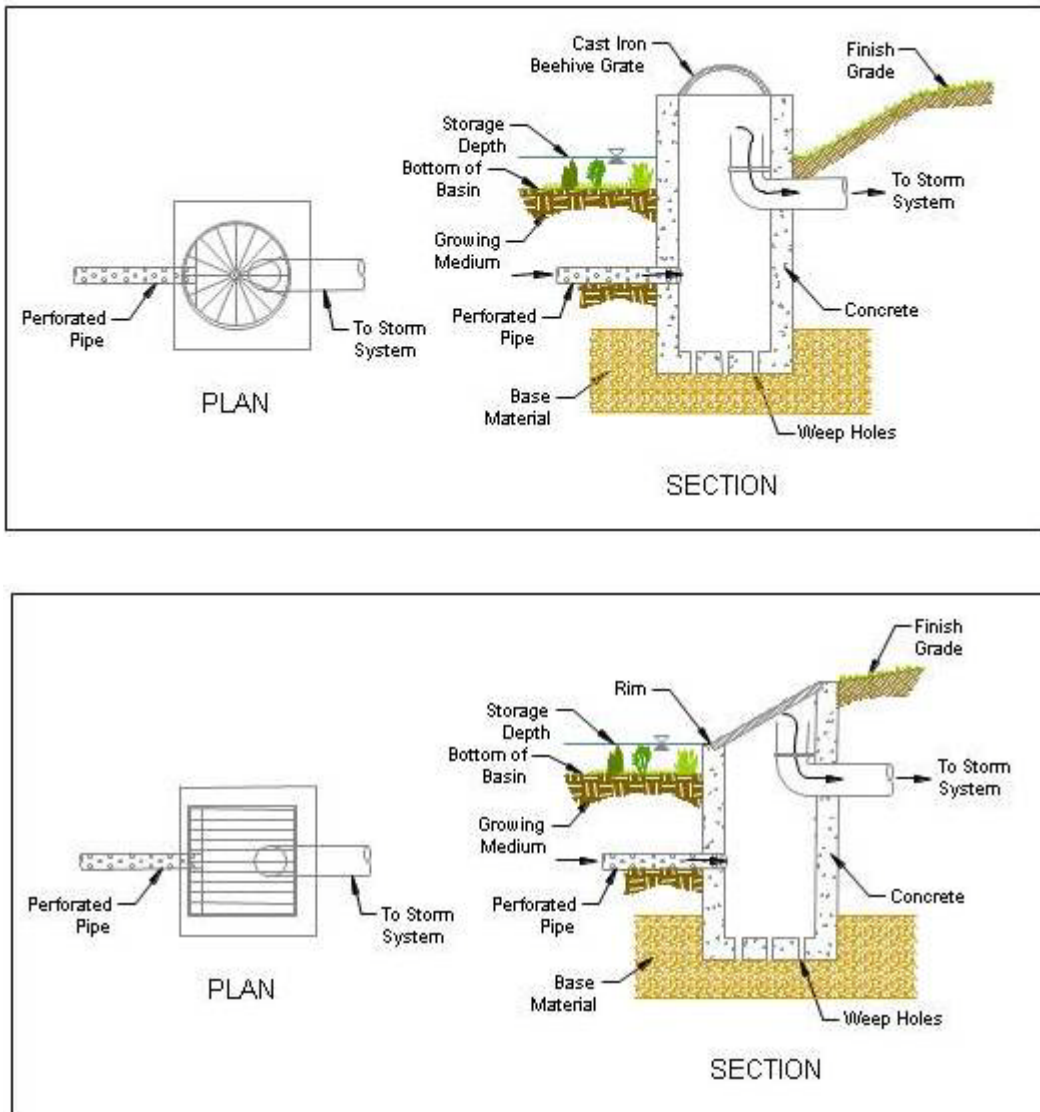


Figure 8. Positive Overflow Options (Section View)

3.6 Permeable Pavement

Permeable pavement includes a wide range of paved or load-bearing surfaces that allow water to pass rapidly through the surface and into the sub-grade that serves as a reservoir, a filter bed, and a load-bearing layer. Permeable pavement provides additional initial interception and captures pollutants.

3.6.1 Requirements

- Permeable pavement systems must be designed to incorporate an underdrain, or a subsurface detention or retention system with the capacity to drain the surface of the system within 24 hours.
- Storage in aggregate or underground structures may be located beneath the paving system to provide detention volume, but these systems must include a liner.
- Permeable pavements are not allowed on driveway aprons, or public streets.
- Voids in the permeable concrete itself may not be counted as detention volume.

3.7 Tree Box Filter

Tree box filters are bioretention systems enclosed in concrete boxes or other sub-surface structures that drain runoff from paved areas via a standard storm drain inlet structure. They consist of a precast concrete (or other) container, a mulch layer, bioretention media mix, observation and cleanout pipes, under-drain pipes, a street tree or large shrub, and a grate cover.

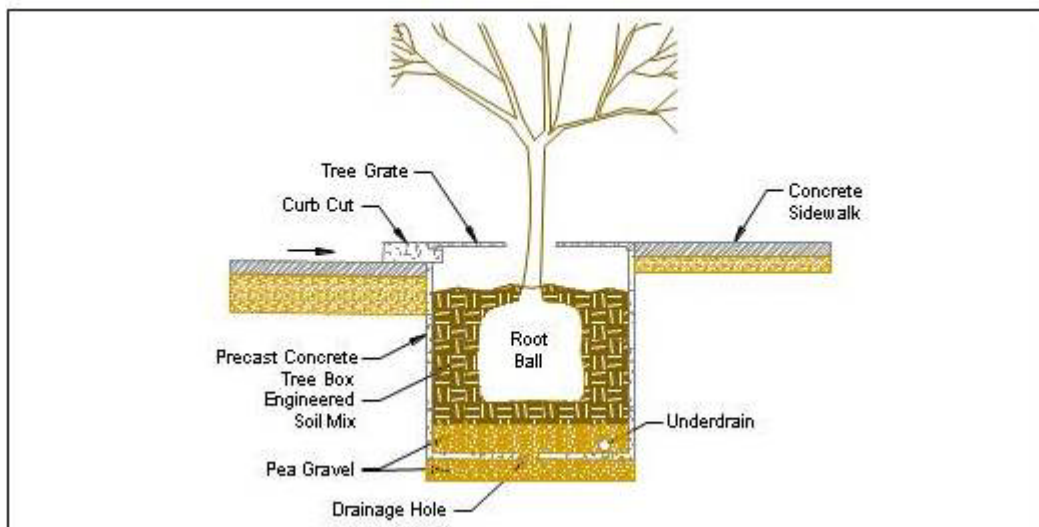


Figure 9. Tree Box Filter

3.7.1 Requirements

- The ponding area in Tree Box Filters shall be designed with a maximum ponding depth of 24” and to drain ponded water within 24 hours.
- Plants can also be selected from those that would be used in traditional bioretention systems (See Appendix A).
- An underdrain pipe is required to drain the feature.
- A maximum of 75% of the void space volume may be counted for detention.
- Pre-manufactured systems must be installed in accordance with the manufacturer’s instructions.

3.8 Storm Water Planter Box

Storm Water Planters, also known as flow through planters, are also bioretention systems in enclosed in concrete structures. They can be designed to drain runoff from paved areas via curb inlet structures or pipes, or they can be located under roof drain downspouts for treatment of roof runoff.

3.8.1 Requirements

- Storm Water Planters shall be designed with an underdrain pipe.
- Waterproofing shall be incorporated into the designs of Storm Water Planters sited near buildings and other structures.
- The ponding area in Storm Water Planters shall be designed with a maximum ponding depth of 24” and to drain ponded water within 24 hours.
- Plants can also be selected from those that would be used in traditional bioretention systems.
- Pre-manufactured systems must be installed in accordance with the manufacturer’s instructions

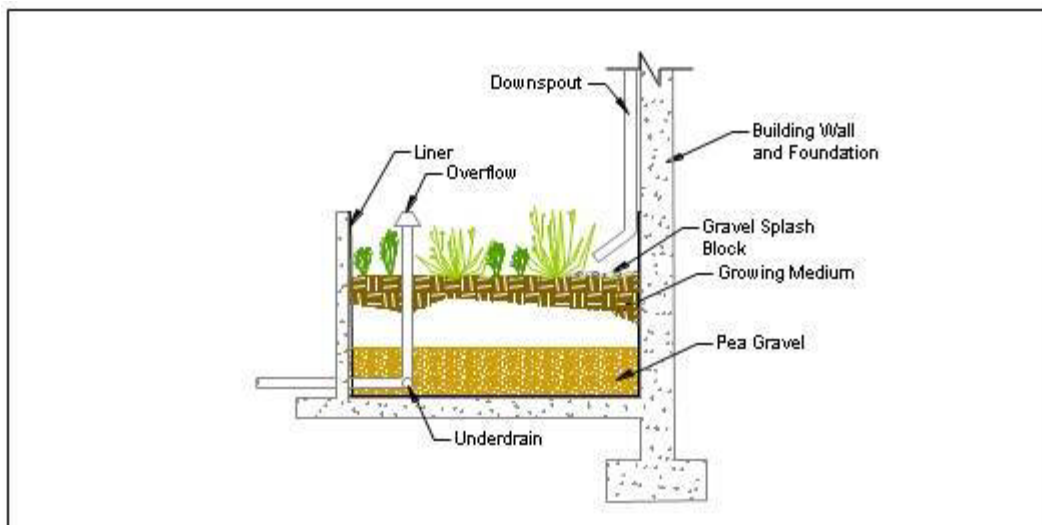


Figure 10. Storm Water Planter Box (Section View)

3.9 Green Roof

A green roof is a vegetated roofing system. Green roofs typically consist of a number of layers: a waterproofing membrane, a drainage system, root protection, growing media (soil) and vegetation. Green roofs provide numerous environmental benefits and offer a valuable tool for integrated storm water management.

3.9.1 Requirements

Green roofs can provide an acceptable storm water quality treatment on the commercial site or non-single family residential structures.

4 LID Design Essentials for Specific Project Types

4.1 Roadways

Harris County Public Infrastructure Division standards for public roads which implement LID practices include those detailed in this section.

4.1.1 General Roadway Criteria for Public Streets

Table 7. General Roadway Requirements

Consideration	Requirements
LID Features	<ul style="list-style-type: none"> • Pervious asphalt or pervious concrete will not be used for the roadway pavement. • Generally, Impacts must be restrained to the road ROW; i.e. no off site detention or mitigation would be required. LID features should be able to fit in the MTFP ROW (i.e. 100ft) • Roadway safety cannot be compromised. • Maintenance intensive features are not acceptable. • LID features cannot be placed beneath travel lanes (median openings acceptable). • All LID features will be incorporated within the Public Right of way, or within a dedicated easement. • Designs must provide safe conveyance of the 100 year event.
Culvert Sizes	<ul style="list-style-type: none"> • Culverts must meet minimum size standard of 18". However, a restrictor on upstream end may be allowed if needed for hydraulic reasons. The minimum restrictor size shall be 6".
Construction Management	<ul style="list-style-type: none"> • This critical element for successful implementation must be addressed in the design.
Hydrology	<ul style="list-style-type: none"> • See Section 2.3
Maintenance	<ul style="list-style-type: none"> • In general, maintenance costs should not be increased to a point that offsets the capital cost savings of the LID design approach. • Design maintenance is to be minimized by landscape choices

	<p>and other decisions that may impact maintenance requirements. (Ideally it would be limited to once or twice per year vegetative maintenance.) Requirements should be clearly spelled out in the design.</p> <ul style="list-style-type: none"> • See Required Maintenance in other sections.
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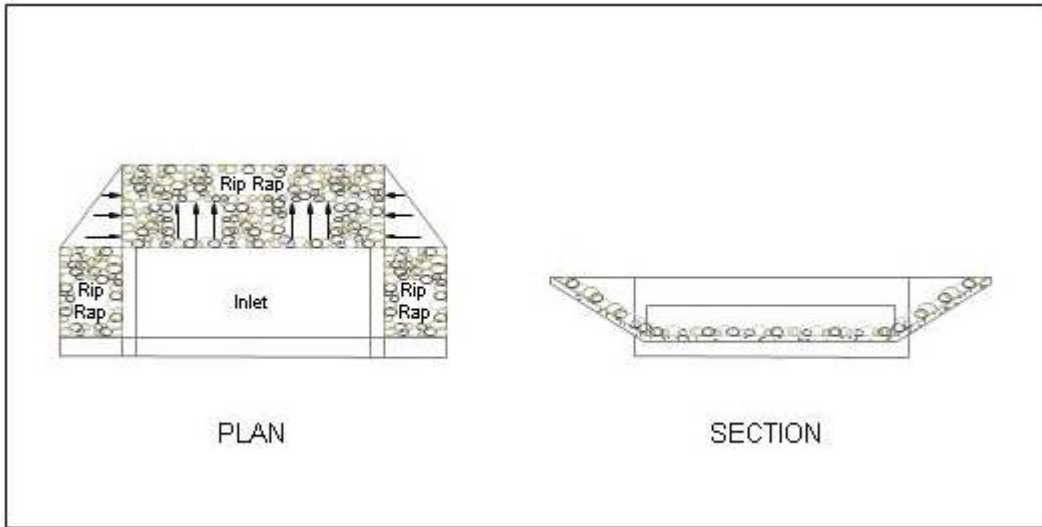


Figure 11: False inlet (preferred)

4.1.2 Criteria for Vegetated Swales in Roadways

Table 8. Criteria for Vegetated Swales in Roadways

Consideration	Requirements
Overflow & Safety	<ul style="list-style-type: none"> • Overflow weir or structures are required, and must accommodate the extreme event. • Overflow inlet grates must be designed to minimize blockage. • Overflow bypass should occur at design maximum ponding depth. • Crossovers may be depressed up to 6" to act as 100 year event overflow weirs, provided crossover is not associated with a major thoroughfare intersection. • Utilize standard minimum curb heights as an option to prevent traffic from entering the swale. • Acceptable inlet styles are those which do not impinge on safety requirements and account for the potential for being clogged with debris, such as: <ul style="list-style-type: none"> ▪ False inlet (preferred) ▪ Curb Cut with recessed flume opening, if top surface bridged. ▪ Horizontally slotted curb at street grade, if sufficiently long. • Inflow inlets to Bioswale should be dropped 3" to assist in capturing sediment before it reaches the Engineered Soil Media and be sufficiently long so as to prevent flow restrictions caused by vegetation.
Water Quality	<ul style="list-style-type: none"> • Vegetated Swales may act as a pretreatment system for water quality, but alone will not meet the water quality requirement to treat the first 1" of runoff.
Detention	<ul style="list-style-type: none"> • Maximum side slope at 4:1, unless approved by the County Engineer.

	<ul style="list-style-type: none"> • Maximum water depth for the 2yr event shall not exceed 2 feet. • Maximum water depth for the 100yr event shall not exceed 4 feet, and one traffic lane in each direction shall remain passable. • In the design, plan for left turn lanes so that this volume is excluded. • Culverts must meet minimum size standard of 18". However, a restrictor on upstream end may be allowed if needed for hydraulic reasons. Minimum restrictor size is 6". • Water shall not pond for more than 24 hours (max). • Maintain the requirement for no adverse impact during an extreme event. • If the design includes taking credit for storing storm water within the voids of engineered soils then appropriate modeling techniques should be used to account for this.
Utilities	<ul style="list-style-type: none"> • Shallow depth of typical LID features may offer beneficial design options with respect to utilities beneath them, but may in some circumstances, limit the use of Bioswales at the outer edges of the ROW.
Vegetation	<p>Vegetation shall be selected based on the following criteria:</p> <ul style="list-style-type: none"> • Hardiness in the design condition, evapotranspiration rate, pollutant removal, maintenance requirements and cost. • Ornamental plant massing should be utilized only where non-standard maintenance capacity exists ('adopt-a-mile' programs, garden club, HOA affiliations, etc.) and grouped to allow for efficient maintenance procedures. • Where maintenance issues are most critical, specify grass-only landscape plans. • Vegetation capable of wet and dry conditions. • Construction timing and seasonal considerations should be considered in the specification of plant material, and erosion control measures.

4.1.3 Criteria for Bioswales in Roadways

Table 9. Criteria for Bioswales in Roadways

Consideration	Requirements
General	<ul style="list-style-type: none"> • See criteria above (Table 8) for Vegetated Swales. • Bioswales by definition incorporate engineered soils and biofiltration of water to an underdrain, storm sewer, or detention structure (see 3.5.2). • Bioswales must infiltrate water through engineered soils to treat the first 1" of runoff. Runoff above this specified amount may bypass into the storm sewer system.
Engineered Soils	<ul style="list-style-type: none"> • Engineered soil must be a designed mix, submitted for approval, but the minimum effective infiltration rate for engineered soils must be designed for at least thirty inches per hour (30"/hr), with a factor of safety of 2. Therefore the actual design capacity of the soil is to be 60"/hr to meet the 30"/hr criteria with safety factor. • Use of mulch should be limited to the use of aged, shredded hardwood bark mulch (not floatable) used only in biofiltration areas of limited size • In situ testing of Engineered Soil Media must be performed to verify that infiltration rate meets specified rate. Failure to meet the design infiltration rate will result in removal and replacement of the media.

4.1.4 Swale Slope-Depth Ratios: Based on a 30' Median

Table 10. Swale Slope Depth Ratios

Slope	Max Depth from Top of Curb	Max Depth 100yr Event	Max Depth 10 yr Event
6:1	2.5	2.2	2.0
5:1	3.0	2.7	2.5
4:1	3.7	3.4	3.0

Note: for the 100-year event, one lane in each direction shall remain passable with a maximum water depth of 4 feet. For events up to the 10 year, the water shall remain below the gutter line with a maximum water depth of 3 feet. Deeper bioswales may require evaluation for the appropriate level of vehicle control or channelization techniques.

4.2 Commercial Development

4.2.1 Location and Maintenance of LID IMPs

If there are no publicly owned facilities on the commercial site, LID practices shall be maintained by the property owner. As they are part of the Storm Water Quality Permit for the site, they shall be maintained as the Storm Water Quality Management Plan dictates. This maintenance generally consists of familiar landscape maintenance and pavement sweeping activities.

4.3 Suburban Residential Development

4.3.1 Location and Maintenance of LID IMPs

For residential subdivision development, all LID IMPs shall be located within a public Right of Way and/or easement maintained by a governmental entity, i.e. Municipal Utility District, etc. As they are part of the Storm Water Quality Permit for the site, they shall be maintained as the Storm Water Quality Management Plan dictates.

4.3.2 Maintenance Declarations

The responsible governmental entity, i.e. Municipal Utility District, etc., must make a "Maintenance Declaration" as to the intent to construct and maintain the LID IMPs. The declaration shall be filed in the real property records, and the file number referencing such declarations shall be located on the subject plat under "notes". An example declaration is located in Appendix C.

4.3.3 Pavement Width

Any proposed deviations from the approved criteria for pavement width and geometry must be discussed with HCPID at the Pre-project meeting and approved by HCPID.

4.3.4 Detention in Roadside Ditches

Storm water detention within roadside ditches may be allowed provided that the detention, roadside ditch, and drainage features adjacent to the roadway are maintained by another governmental entity other than Harris County, i.e. a Municipal Utility District, etc.

Appendix A LID IMPs General Reference Material

1 LID Integrated Management Practices (IMP)

Although the LID toolbox is virtually unlimited, the practices described below are believed to be the most likely to be used in this area, in combination or alone, to achieve the goals of a LID-based project design. The table below presents the variety of runoff management functions provided by LID IMPs.

Table 11. LID IMP Runoff Management Functions

IMP	Effect or Function					
	Slow Runoff	Filtration	Retention	Detention	Evaporation	Water Quality
Disconnection	X	X				X
Soil Amendment		X				X
Vegetated Filter Strip	X	X			X	X
Vegetated Swale	X	X		X	X	X
Rainwater Harvesting			X	X		X
Bioretention	X	X		X	X	X
Permeable Pavement	X	X		X	X	X
Tree Box Filter	X			X		X
Storm Water Planter	X	X		X	X	X
Green Roof	X				X	X

1.1 Disconnection

Roofs, roads, and driveways account for a large percentage of post-development imperviousness. These surfaces influence storm water quality and runoff volume by facilitating the rapid transport of storm water and collecting pollutants from rainfall, automobiles, and additional sources. Disconnecting storm water can be achieved through identifying the source of runoff and how it will be managed once disconnection occurs. Disconnection is ideal for most single-family developments, but can also be applied to many development sites, including larger office parks and retail centers. This IMP can help reduce total volume and peak rates of runoff when runoff is directed to other IMPs. Disconnection can help reduce runoff volume and peak rates; to the extent that it is absorbed via amended soils or captured in rain gardens otherwise it is only slowed down before reaching the receiving conveyance system.

Taking steps to increase the permeability of soils can also play a valuable role in disconnection. Tilling and amending soils with compost or other amendments can increase permeability and enhance vegetative growth, both of which can assist in the reduction of volume and peak rates.

1.1.1 Disconnecting Roof Runoff

Minimize storm water volume by disconnecting roof leaders. In addition to directing runoff to vegetated areas, runoff may also be discharged to non-vegetated IMPs, such rain barrels, and cisterns for storm water irrigation and water planning purposes. Disconnection of small runoff flows can be accomplished in a variety of ways:

- Encourage shallow sheet flow through vegetated areas.
- Direct roof leader flow into BMPs designed specifically to receive and convey rooftop runoff.
- Direct flows into stabilized vegetated areas, including swales and bioretention areas.
- Rooftop runoff may also be directed to onsite depression storage areas.
- The entire vegetated “disconnection” area should have a maximum slope of five percent.
- Roof downspouts or curb cuts should be at least 10 feet away from the nearest connected impervious surface to discourage “re-connections.”
 - Limit the contributing impervious area to a maximum of 1,000 sq. ft. per discharge point.
 - Limit the contributing rooftop area to a maximum of 1,000 sq. ft. per downspout, where pervious area receiving runoff must be at least twice this size.

1.1.2 Disconnecting Impervious Surfaces

Reductions in peak flows may be gained by redirecting and dissipating concentrated flows from impervious areas onto vegetated surfaces. Strategies for accomplishing this include: directing flows from small swales to stabilized vegetated areas; breaking up flow directions from large paved surfaces; and encouraging sheet flow through vegetated areas.

1.2 Vegetated Swale

Vegetated Swales are broad, shallow channels designed to convey and filter storm water runoff while slowing runoff and removing gross pollutants. They handle runoff from small drainage areas at low velocities. The bottom and sides of the swale are vegetated, with side vegetation at a height greater than the maximum design depth.

Storm water runoff is conveyed along the length of the low slope channel, and the vegetation traps sediments, decreases the velocity of overland flows, and reduces erosion. Vegetated Swales treat runoff by filtering sediments and associated pollutants through the vegetation, and by infiltration into underlying soils if in situ soils are conducive to infiltration.

Check dams are typically used in Vegetated Swales to act as flow spreaders, inducing sheet flow along the swale. They may also be used as a storm water detention mechanism, to encourage sedimentation and to reduce runoff velocity. Vegetated Swales can be used to convey and treat runoff from parking lots, buildings, roadways, and residential, commercial, industrial, and municipal land uses. They can also be used as pretreatment devices for other structural treatment controls.

1.3 Vegetated Filter Strip

A vegetated Filter Strip is a band of dense vegetation, usually grass, planted between a pollution source (e.g., roadway, rooftop downspout, etc.) and a downstream receiving water body or conveyance. They function by slowing runoff, trapping sediment and pollutants, and in some cases infiltrating a portion of the runoff into the ground. Filter strips are a sensible and cost-effective storm water management pretreatment option applicable to a variety of development sites including roads and highways. Given that vegetation is the key functional component of a vegetated filter strip, due consideration must be given to the ability of the in-situ soil to support healthy vegetative growth conditions.

1.3.1 Soil Amendment

The 'sponge' effect of in situ soils in Vegetated Filter Strips may be significantly improved when tilled and amended with compost to enhance pollutant removal, reduce surface ponding time and slow runoff by enhancing vegetative cover. Soil amendments may also be selected to adjust pH to levels supportive of vegetative growth, provide necessary nutrients and minerals, and increase water access and availability characteristics among other benefits. Check dams are typically used in Vegetated Swales to act as flow spreaders, inducing sheet flow along the swale. They may also encourage sedimentation and reduce runoff velocity. Surface ponding in a Vegetated Swale must not exceed 24 hours.

Vegetated Swales can be used to convey and treat runoff from parking lots, buildings, roadways, and residential, commercial, industrial, and municipal land uses. They can also be used as pretreatment devices for other structural treatment controls.

1.3.2 Vegetation Considerations

Given that vegetation is the key functional component of a vegetated swale, due consideration must be given to the ability of the in-situ soil to support healthy vegetative growth conditions. A soil profile which has been cut to create the swale will often expose soils which are not capable of supporting growth without significant, ongoing use of fertilizers which is unlikely to be carried out over the long term. A substantial layer of topsoil retained from the site during the grading phase or imported, and placed over the cut slopes, may alleviate the problem. Vegetation is not restricted to grasses, but regardless of the plant material selected, native plants are preferred. A soil analysis is highly recommended for any Vegetated Swale design, to determine what, if any, amendments may be needed to encourage and ensure proper vegetative growth.

1.3.3 Maintenance Requirements

Proper maintenance includes mowing/pruning, weed control, removal of trash and debris, and reseeding of non-vegetated areas/replacement of plant material. Inspect Vegetated Swales at least twice annually for damage to vegetation, erosion, and sediment accumulation. Sediments should be removed when depths exceed 3 inches. If hazardous materials spill and contaminate soils in vegetated swales, the affected soils should be removed, properly disposed of, and replaced.

1.4 Rainwater Harvesting

Cisterns and rain barrels are designed to capture roof runoff for reuse. Cisterns reduce the runoff volume and may reduce the peak flow rate for small, frequently occurring storms. Cisterns or rainwater catchment systems can provide a storm water management solution where impervious surfaces are unavoidable and site constraints limit the use of other LID practices. Such situations may include highly urbanized areas (such as downtown centers), or dense housing developments without adequate space for storm water infiltration or detention, or where soil and groundwater conditions do not permit infiltration. In addition to storm water management benefits, rainwater catchment systems can be utilized as a sustainable building approach to reduce a development's dependence on municipal water supplies.

There are several management and maintenance factors for the rain water catchment system that should be considered including the fact that the storage capacity needs to be available to catch the next storm event's flow. For example, if the water in the storage tank is only used for landscape irrigation and the need for irrigation water during a period of extended rainfall is minimal, the tank may fill after the first few storms and overflow during subsequent storms. Therefore, rainwater catchment systems that are only used for landscape irrigation may not be effective for storm water management during the rainy season. Development of a water budget should be conducted for maximum efficiency and is required to demonstrate how rainwater harvesting is used to reduce the storm water detention requirement.

1.5 Bioretention Systems (Bioretention Cell, Rain Garden, Bioswale)

Bioretention is a terrestrial-based (up-land as opposed to wetland), water quality and water quantity control practice using the chemical, biological and physical properties of plants, microbes and soils for biofiltration and the removal of pollutants from storm water runoff. Bioretention Cells or Rain Gardens are vegetated depressions, filled with an engineered soil media which provides biofiltration for removal of pollutants, increases time of concentration, may provide detention and prevents surface ponding of storm water. The Bioswale is linear version of a Bioretention Cell and has similar design considerations, requirements and attributes. Bioswales are typically designed for primary or secondary conveyance as well as its bioretention and biofiltration benefits.

1.5.1 Design Considerations

A typical bioretention system design includes a depressed ponding area (at a grade below adjacent impervious surfaces), an engineered soil mix, and an underdrain or underground detention or water harvesting system.

Bioretention facilities are typically excavated to a minimum depth of 1 to 3 feet, Excavation depth is typically based on depth to the seasonal high groundwater table, outfall depth considerations and volume to be captured. Deeper excavation allows for additional storage in the engineered soil, gravel layers, underdrain or underground detention/storage structures. Unless the system is being constructed without an underdrain, a layer of geotextile filter fabric or an impermeable liner (if surrounding infrastructure dictates) should be placed along the sides and bottom of the excavation to separate the engineered soils from the existing site soils.

Engineered soil media occupies the remaining excavated space above the underdrain system, leaving room for the desired amount of surface ponding. The area is then mulched and planted with shrubs, perennials, grasses, and small trees. When shrubs and flowers are used as the plant material, a 2 to 3 inch layer of mulch is used on top of the media. The mulch acts as a pretreatment device to protect the underlying media and helps to retain some water in the media for the health of the plant.

Generally runoff is ponded to a maximum depth of approximately 12-24 inches and then gradually filters through the engineered soil media, where it is retained in the porous soils, utilized by plants, evapotranspired, and either infiltrated into the underlying soils (when applicable), or drained into an underdrain or underground storage system over a period of hours. The Bioretention system should be designed so that surface ponding does not exceed 24 hours.

The layout of a Bioretention system should be determined based on site constraints such as location of utilities, underlying soil conditions, existing vegetation and drainage patterns. The plant selection and layout should consider aesthetics, maintenance, native versus non-native, invasive species, and regional landscaping practices. It should be noted that ideal plants for a typical Bioretention system are drought and inundation tolerant.

An important design factor to consider when applying Bioretention to development sites is the scale at which it will be applied. Typical system scales are:

- Bioretention Cells or Rain Gardens are small, distributed practices designed to treat runoff from small areas. Inflow is typically sheet flow, or can be concentrated flow with energy dissipation.
- Bioretention Basins are larger systems treating parking lots and/or commercial rooftops, or other large areas, usually in commercial or institutional areas. Inflow can be either sheet flow or concentrated flow. Bioretention basins may also be distributed throughout a residential subdivision for instance, but in this case they should be located in common area or within drainage easements, to treat a combination of roadway and lot runoff.
- Urban Bioretention structures include systems such as Tree Filters, Curb Extensions, and Planter Box Filters.

1.5.2 Engineered Soil Media

The infiltration rate of Engineered Soil Media in a bioretention facility must be designed to treat the first 1" of runoff volume from the drainage area it serves. In order to minimize maintenance needs and insure performance, the Design Infiltration Rate (inches per hour) must account for potential future degradation and therefore, must provide a minimum safety factor of 2.

The Engineered Soil Media shall be placed and graded using low ground-contact pressure equipment or by excavators and/or backhoes operating on the ground adjacent to the bioretention facility. No heavy equipment shall be used within the perimeter of the bioretention facility before, during, or after placement of the media. The Engineered Soil Media shall be placed in horizontal layers not to exceed 12 inches for the entire area of the bioretention facility. It shall be compacted by saturating the entire area of the bioretention facility after each lift is placed until water flows from the underdrain. Water for saturation shall be applied by spraying or sprinkling. An appropriate sediment control device shall be used to treat any sediment-laden water discharged from the underdrain. Final grading of the Engineered Soil Media shall be performed after a 24-hour settling period.

For quality control purposes, the supplier of the Engineered Soil Media must provide a certificate which indicates the infiltration rate of the media on delivery to the project site. An in situ test must be conducted on site after engineered soil media is placed and settled, to insure that it meets the design infiltration rate. This test shall be conducted using a field Infiltrometer, as outlined in Appendix B.

The Engineered Soil Media depth should be determined based on the mature root depth of the selected vegetation, (typically between 18 and 24 inches). Trees and larger shrubs may require a greater soil depth.

1.5.3 Mulching

Once the plants are in place, the entire bioretention facility shall be mulched to a uniform thickness of 3 inches. Well aged (minimum age of 6 months) shredded hardwood bark mulch is the only acceptable mulch.

1.5.4 Flow Inlet

The flow entrance of the Bioretention facility is an important component of the bioretention. The best method of capturing and treating runoff is to allow the water to sheet flow into the facility over grassed areas. This is not always possible, especially where site constraints or space limitations impede such an approach. A remedy to this problem is to provide flow inlets that can reduce the velocity of the water. In the case of parking lot landscape islands, curb cuts protected with energy dissipaters such as landscape stone can be used. It is important to note that entrances of this type will tend to become obstructed with sediment and trash that settles out at lower velocities. This is not a problem as long as routine parking lot maintenance is performed. The trapped sediment along the curblines provides a convenient location for parking lot sweeping. On occasion, accumulated sediment and debris should be removed from the flow entrance area if the accumulation is obstructing flow into the facility itself.

Erosion control and energy dissipation features should always be provided where concentrated runoff enters bioretention systems (e.g. cobbles or riprap beneath a curb-cut opening or a splash block beneath a roof drain downspout). In addition:

- Vegetated swales or filter strips can be added to the design to provide pretreatment (e.g. for sediment reduction).
- Trench drains can accept runoff from impervious surfaces and convey it to a bioretention facility. The trench drain may discharge to the surface of the system or may connect directly to an aggregate infiltration bed beneath.
- Curbs can be used to direct runoff from an impervious surface along a gutter to a low point where it flows into the bioretention system through a curb cut. Curb cuts may be depressed curbs, full height curbs with openings cast or cut into them or may be “false” inlets, designed to look like a traditional curb inlet.

1.5.5 Underdrain

The role of an underdrain in the bioretention facility is to ensure proper drainage for the plants and to ensure proper infiltration rates occur so as to avoid standing water for extended periods. Underdrains are configured in many different ways and typically include a washed gravel/stone “blanket” encompassing a horizontal, perforated discharge pipe or other perforated drainage system. A pea gravel separation layer as

described above can be used between the under drain's aggregate blanket and the Engineered Soil Media to protect the underdrain from blocking. Underdrains keep the soil at an adequate aerobic state, allowing plants to flourish.

Underdrain structures, including subsurface detention or storage structures which are used under Bioretention systems must have a total opening area which exceeds the expected flow capacity of the underdrain itself.

To estimate the capacity of flows through the perforations, orifice flow conditions are assumed and a sharp-edged orifice equation can be used. First, the number and size of perforations needs to be determined (typically from the manufacturer's specifications) and used to estimate the flow rate into the pipes using the head of the Engineered Soil Media depth plus the ponding depth. Second, it is conservative but reasonable to use a blockage factor to account for partial blockage of the perforations by the drainage layer media. A safety factor of two is required.

This aggregate layer surround the underdrain should consist of washed aggregate ½"-1½" in diameter. Placement of the gravel over the underdrain must be done with care. Avoid dropping the gravel high levels from a backhoe or front-end loader bucket. Spill directly over underdrain and spread manually.

Underdrains must discharge into an adequate conveyance system. The underdrain system should be sized to support the flow rate of the engineered soils and the volume of water entering. Discharge from the underdrain can be routed to a down gradient storm drain pipe or channel or another IMP device. The underdrain system should have a vertical solid section that extends above the surface of the ponding area in the basin to provide a monitoring well and clean out access port.

In some cases, a liner may be necessary to avoid infiltration into surrounding soils and/or groundwater. Examples include facilities located in Brownfields, or in close proximity to structures or roadbeds, or in areas where there is outdoor storage or use of chemicals or materials within the drainage area that could threaten groundwater quality if a spill were to occur.

1.5.6 Positive Overflow

A positive overflow, via the surface or subsurface, is required to safely convey excessive runoff from extreme storm events. Bioretention systems should include design features that allow flows from relatively large storm events to either bypass the system or overflow to a conventional storm drain structure such as a channel, a curb and gutter system, or a storm drain overflow inlet. Off-line designs are an option and are best accomplished when only one inlet is present in the bioretention system. Once the bioretention facility is full, the high flows would bypass the inlet. Bypass flows or overflows can also be routed to another downstream storm water treatment system such as a vegetated swale or an extended detention basin.

1.5.7 Required Maintenance

One of the major advantages of a bioretention system over any underground BMP is that inspection is easy since the system is in full view to inspect the health of the plants and amount of debris or sedimentation that has accumulated. Once plants are established, only minimal plant maintenance and occasional removal of sediment and debris is necessary. Mulch should be replaced on an annual basis. Other considerations include:

- Upon installation and during the first year, Bioretention systems should be inspected monthly for potential erosion and/or extended ponding.
- Key inspection/maintenance areas include inlet and overflow areas for potential erosion, the ponding area for trash and debris, and the Observation/Cleanout Standpipe for potential early signs of stagnant water in the system if an underdrain system is included.
- Inspections can be reduced to a semi-annual schedule once the system has proven to work properly and vegetation is well established.
- An evaluation of the health of the plants, trees and shrubs should be conducted biannually.
- Pruning, weeding and trash removal should be conducted as necessary.
- Mulch replacement is generally required every year.
- If ponding is observed to exceed 24 hours, particularly during the primary mosquito breeding season (June through October), the reason for the extended ponding should be determined and mitigated.
- If a spill occurs and hazardous materials contaminate soils in landscape detention areas, the affected materials should be removed immediately and the appropriate engineered soil media and materials replaced as soon as possible.

1.6 Permeable Pavement Systems

Permeable pavement includes a wide range of paved or load-bearing surfaces that allow water to pass rapidly through the surface and into the sub-grade that serves as a reservoir, a filter bed, and a load-bearing layer. Permeable pavement decreases the runoff volume and peak flow rate and captures pollutants. These systems allow for infiltration of storm water while providing a stable load-bearing surface for walking and driving. Porous pavement detention can be used as a substitute for conventional pavement, but should be limited to parking areas and low traffic volume roadways where little to no truck traffic is anticipated.

Example applications include residential street parking lanes, parking stalls in commercial or retail parking lots, overflow parking areas, maintenance walkways/trails, emergency vehicle and fire access lanes, stopping lanes on divided highways, equipment storage areas, and patios. Permeable pavements may not currently be used on residential driveways or major thoroughfares.

Permeable pavement treats rainfall that falls directly on the surface, as well as runoff from adjacent impervious areas. These systems contain void spaces to provide infiltration of runoff into their underlying engineered porous materials and then into existing site soils. Generally, underlying engineered materials consist of clean sands or gravels separated from existing site soils by a synthetic filter fabric. Underlying engineered materials detain and filter pollutants prior to infiltration into underlying soils or discharge to a conventional storm drain system through an underdrain system. With these systems, it is important to note that the load-bearing sub-grade must be sufficiently thick to support the design load from the intended use and provide storage for volume or detention control. Porous paving systems can preserve natural drainage patterns, enhance groundwater recharge and soil moisture, and can help establish and maintain roadside vegetation. Although a good substitute for conventional concrete and asphalt in certain applications such as parking lots or long private driveways, porous paving systems are not suitable in high-traffic areas.

All installations of permeable pavement systems should be carried out according to manufacturer's specifications. There are several types of Permeable Pavement systems, including:

- Open Celled Block Pavers
- Open Jointed Block Pavers
- Porous Asphalt Pavement
- Porous Concrete Pavement
- Porous Turf
- Porous Gravel
- Open-Celled Plastic Grids

1.6.1 Underdrain

Permeable pavement systems must be designed to incorporate an underdrain/subsurface detention or retention system with the capacity to drain the surface of the system within 24 hours. Storage in aggregate or underground structures may be located beneath the paving system to provide additional detention volume, but these systems must be lined with an impermeable liner.

1.6.2 Required Maintenance

The overall maintenance goal is to avoid clogging of the void spaces. Remove accumulated debris and litter as needed. Inspect Permeable Pavement systems several times during the first few storms to insure proper infiltration and drainage. After the first year, inspect at least once a year.

Permeable pavements and materials should be cleaned with a vacuum-type street cleaner at least twice a year to prevent clogging of the pervious surface. Hand held pressure washers can be effective for cleaning the void spaces of small areas with some pavement systems and should follow vacuum cleaning. Maintenance personnel must be instructed not to seal or pave with non-porous materials.

Vegetated paving systems require careful vegetative maintenance to insure the health and viability of the vegetation.

1.7 Tree Box Filter

Tree box filters are bioretention systems enclosed in concrete boxes or other sub-surface structures that drain runoff from paved areas via a standard storm drain inlet structure. They consist of a precast concrete (or other) container, a mulch layer, bioretention media mix, observation and cleanout pipes, under-drain pipes, a street tree or large shrub, and a grate cover. The filters are installed below grade at the curb line. For low to moderate flows, storm water enters the tree box inlet, percolates through the media, and exits through an underdrain into the storm drain. For high flows, storm water bypasses the tree box filter once it becomes full and flows directly to the downstream curb inlet. As an engineered media-based filter, tree box filters remove pollutants through the same physical, chemical, and biological processes as traditional bioretention systems. Under normal conditions, pretreatment is not necessary. Most of the general design standards noted previously for bioretention systems also apply to tree box filters. Tree box filters should generally be designed per the bioretention system design criteria and engineered media testing requirements.

1.8 Storm Water Planter Box

Storm Water Planters, also known as flow through planters, are also bioretention systems in enclosed in concrete structures. They can be designed to drain runoff from paved areas via curb inlet structures or pipes, or they can be located under roof drain downspouts for treatment of roof runoff. They should be designed with an underdrain pipe. Waterproofing should be incorporated into the designs of Storm Water Planters sited near buildings and other structures.

Most of the general design standards noted above for bioretention systems also apply to storm water planters. For example, the ponding area in Storm Water Planters should be designed with a maximum ponding depth of no more than 12-24" and to drain ponded water within 24 hours. Plants can also be selected from those that would be used in traditional bioretention systems.

1.9 Green Roof

A green roof is a vegetated roofing system. Green roofs typically consist of a number of layers: a waterproofing membrane, a drainage system, root protection, growing media (soil) and vegetation. Green roofs provide numerous environmental benefits and offer a valuable tool for integrated storm water management.

Green roofs may cover all or part of a building's roof. Green roofs retain rainfall from small, frequently occurring storms through storage in the soil. In turn, this water is lost to evaporation or transpiration by plants. For larger storms, the runoff volume and peak flow rate is reduced because of percolation and temporary storage in the soil. Green roofs improve water quality through a variety of physical, biological and chemical processes in the soil.

Structurally, there are two types of green roofs: extensive and intensive. Extensive green roofs are lightweight vegetated roofs typically consisting of 4-8 inches of growth media (or soil), planted with hardy, drought-tolerant species to minimize additional irrigation, maintenance, cost and weight. They typically require supplemental irrigation to support growth during initial establishment of vegetation and during extended dry periods. Modular green roof systems are available that can come pre-planted in ready-to-install blocks. Alternatively, intensive green roofs can be designed to support lawns, trees, and create a useable outdoor garden space; often referred to as roof gardens. While these amenities do not preclude environmental benefits of green roofs, they do require extra structural support, cost, and have functional goals in addition to storm water management objectives. They also typically require supplemental irrigation systems.

1.9.1 Required Maintenance

Upon installation, the green roof system should be inspected monthly for the first year and after each large storm event for erosion, plant survival, proper drainage, and waterproofing. Inspections can be reduced to a quarterly schedule once the green roof system has proven to work properly and vegetation is established. If necessary, irrigate in short bursts only (3-5 minutes) to prevent runoff. Irrigation frequencies should be established by the designer using an automated system. Clean out drain inlets as needed. Weeding and mulching may be necessary during the establishment period, depending on the planting design. Replace or fill in vegetation as needed. Inspect soil levels semi-annually to ensure plant survival and rainfall absorption.

2 LID Landscaping Design

Landscaping is a critical component of bioretention because of the natural ability for plant material to treat pollutants in urban storm water. The integration of landscaping also sets bioretention apart from other integrated management practices by allowing the storm water practice to be distributed throughout the site - closer to the pollution sources - while improving the site aesthetics. With the proper landscaping application of bioretention, most people interacting with the built environment will tend to admire the sites aesthetics and not even be aware that storm water management exists on the site.

Key factors in the design of bioretention facilities are careful selection of plant materials that can tolerate highly variable hydrologic changes and an overall planting plan that ecologically and aesthetically blends the facility into the landscape. Designing for ease of maintenance is also a critical element of any landscape plan.

Consider interactions with adjacent plant communities including the potential to provide links to wildlife corridors. Adjacent plant communities should be evaluated for compatibility with any proposed bioretention area species. Nearby existing vegetated areas dominated by non-native invasive species pose a threat to adjacent bioretention areas. Invasive species typically develop into monocultures by out-competing other species. Mechanisms to avoid encroachment of undesirable species include providing a soil breach between the invasive communities for those species that spread through rhizomes and providing annual removal of seedlings from wind borne seed dispersal. It is equally important to determine if there is existing disease or insect infestations associated with existing species on site or in the general area that may affect the bioretention plantings.

2.1 Soil Amendment

The 'sponge' effect of in situ soils may be significantly improved when tilled to depth of at least 6" and incorporating at minimum of 2" of compost within the root zone to improve soil quality, plant viability and soil hydraulic conductivity, which enhances time of concentration, provides enhanced pollutant removal and reduces surface ponding time. This practice is typically utilized for Vegetated Swales and Vegetated Filter Strips, but should be strongly considered for general landscape and turf areas.

Prior to soil amendment, existing soils must be sampled and evaluated to determine amendment quantities and plan the amending process. In addition to compost, soil analysis may reveal the need for other soil amendments, such as lime, gypsum and specific nutrients.

Compost shall be mature, stable, weed free, and produced by aerobic decomposition of organic matter. The product must not contain any visible refuse or other physical contaminants, substances toxic to plants, or over 5% sand, silt, clay or rock material by dry weight. The moisture level shall be such that no visible water or dust is produced when handling the material.

The results of compost analysis shall be provided by the compost supplier. Before delivery of the compost, the supplier must provide the following documentation:

- feedstock percentage in the final compost product
- a statement that the compost meets federal and state health and safety regulations
- a statement that the composting process has met time and temperature requirements

- a copy of the lab analysis, less than four months old, performed by a Seal of Testing Assurance Certified Laboratory verifying that the compost meets the physical requirements as described.

Compost shall uniformly be applied over the entire area to a depth of two (2) inches, and incorporated into the soil to a minimum depth of six (6) inches. Where tree roots or other natural features limit the maximum depth of incorporation, compost quantities should be adjusted. Required volume of compost may be estimated using the following approximation: one (1) inch compost spread over 1000 square feet = three (3) cubic yards. The Designer may specify different compost application rates depending upon soil conditions.

2.2 Mulching

Once the plants are in place, the entire bioretention facility shall be mulched to a uniform thickness of three (3) inches. Well aged (minimum age of six [6] months) shredded hardwood bark mulch is the only acceptable mulch.

2.3 Plant Species Selection

The role of plant species in the bioretention concept is to bind nutrients and other pollutants by plant uptake; to remove water through evapotranspiration; and to create pathways for infiltration through root development and plant growth. Root growth provides a media that fosters bacteriologic growth, which in turn develops a healthy soil structure. A variable plant community structure is preferred to avoid monoculture susceptibility to insect and disease infestation and to create a microclimate, which ameliorates urban environmental stresses including heat and drying winds. Parking lot island bioretention is particularly susceptible to extended dry conditions. A layered planting scheme will help discourage weeds as well as creating suitable microclimates. There are many potential side benefits to the use of planting systems other than water quality and quantity treatment. Planting systems, if designed properly, can improve the value of the site; provide shade and wind breaks; improve aesthetics; support wildlife; and absorb noise.

3 Landscape Maintenance

All landscape treatments require maintenance. Landscapes designed to perform storm water management functions are not necessarily more maintenance intensive than highly manicured conventional landscapes. A concave lawn requires the same mowing, fertilizing and weeding as a convex one and less irrigation after rain is filtered into the underlying soil. Sometimes infiltration basins may require a different kind of maintenance than conventionally practiced.

Typical maintenance activities include periodic inspection of surface drainage systems to ensure clear flow lines, repair of eroded surfaces, adjustment or repair of drainage structures, soil cultivation or aeration, care of plant materials, replacement of dead plants, replenishment of mulch cover, irrigation, fertilizing, pruning and mowing. Landscape maintenance can have a significant impact on soil permeability and its ability to support plant growth. Most plants concentrate the majority of their small absorbing roots in the upper 6 inches of the soil surface if the surface is protected by a mulch or forest litter. If the soil is exposed or bare, it can become so hot that surface roots will not grow in the upper 8 to 10 inches. The common practice of removing all leaf litter and detritus with leaf blowers creates a hard crusted soil surface of low

permeability and high heat conduction. Proper mulching of the soil surface improves water retention and infiltration, while protecting the surface root zone from temperature extremes.

In addition to impacting permeability, landscape maintenance practices can have adverse effects on water quality. Because commonly used fertilizers and herbicides are a source of organic compounds, it is important to keep these practices to a minimum, and prevent over watering. Over watering can be a significant contributor to run off and dry weather flows. Watering should only occur to accommodate plant health when necessary. When well-maintained and designed, landscaped concave surfaces, bioretention systems, vegetated swales and other LID IMPs can add aesthetic value while providing the framework for environmentally sound, comprehensive storm water management systems.

4 Putting LID into practice

4.1.1 Collaborative Design

Successful sustainable design is inherently a collaborative process. Collaboration by integrated design teams representing all the key areas of the design, permitting, construction, and development process must work together to insure an ideal outcome. While this has become standard operating procedure in green building, it has not always translated into site development.

This Guide, and the collaborative permitting process which it informs, seeks to insure a process in which all parties benefit from the opportunities to learn as we determine the best adaptations, applications and implementations of Low Impact Development and Green Infrastructure practices in our community.

4.2 Construction

The effectiveness of LID systems is a function of the design and the construction techniques employed. Of these two parameters, construction is perhaps more critical at achieving quality results. Poor construction techniques will cause the best designed IMP to fail prematurely, usually from sedimentation and/or clogging.

4.2.1 Training

It is very important that contractors, vendors, and inspectors be properly trained in the design specification and construction requirements for all LID practices employed. The success of many LID techniques depends on accurately following the grading plan; the use of proper materials and the appropriate location of practices. Due to the complexities of the practice, it may be necessary for vendors, contractors, and permit personnel to participate in training classes. For example, the design and construction of bioretention cells requires the knowledge of several disciplines including engineering, landscape architecture, and soil science to ensure the proper design and construction of the project.

4.2.2 Communication

LID uses innovative techniques, unique strategies and various combinations of practices. Consequently, each development results in a unique design with its own set of issues and challenges. It is vital that everyone involved in the LID project (contractors, vendors, design engineers, and inspectors) understands

the unique details of the LID project. A pre-construction meeting is the most useful approach to ensure that the project goals and issues are effectively communicated. Ideally the contractor, vendor, design engineer, and inspector should hold a meeting to go over the plans and discuss all aspects of the project. During the pre-construction meeting, the inspector may evaluate the proposed sequence of construction, sediment control requirements, and indicate when inspection points during construction of the LID practices are required as identified in the design manual.

Throughout the construction process, there must be effective communication. No construction project takes place without unforeseen problems and the need to make some field adjustments. Proper lines of communication must be in place throughout the construction phase between the general contractor, site engineer, inspector, and permit staff to address required changes. Designers must also make it a priority to make construction sequencing and details conspicuous on plans.

4.2.3 Erosion and Sediment Control

Proper erosion and sediment control during construction is vital for LID practices. If existing vegetation is to be used for treatment (bioretention, swales or buffers), then these areas must be protected from sedimentation. Areas that may be used for biofiltration must be protected to prevent sediment from clogging soils with silts and clays. Preventing damage from sedimentation is less expensive than cleaning or rehabilitating an area.

4.2.3.1 Storm Water Pollution Prevention (SWPPP) During Construction

The clearing, grubbing and scalping (mass clearing or grading) of excessively large areas of land at one time promotes erosion and sedimentation problems. On the areas where disturbance takes place the site designer should consider staging construction, temporary seeding and /or temporary mulching as a technique to reduce erosion. Staging construction involves stabilizing one part of the site before disturbing another. In this way the entire site is not disturbed at once and the duration of soil exposure is minimized. Temporary seeding and mulching involves seeding or mulching areas that would otherwise lie open for long periods of time. The time of exposure is limited and therefore the erosion hazard is reduced. Two methods of sediment control are typically applied to bioretention facilities as follows.

The first method (most typical) is to direct all drainage away from the locations of IMPs to avoid excessive sedimentation. Flow can be directed away from the bioretention IMP by utilizing silt fencing materials, wattles and temporary diversion swales

The second method of erosion and sediment control design allows the area proposed for the bioretention IMP to be used as a temporary sediment control structure. If a sediment control structure is to become a bioretention IMP, the sediment materials shall be removed prior to constructing the bioretention IMP and placing the Engineered Soil Media.

4.2.4 Tree Protection

Care must be taken to protect tree conservation areas during construction. Tree conservation areas are ineffective if the trees die shortly after the project is completed.

In order to effectively protect trees, it is important to consider the following during any construction process:

- All types of construction equipment can cause mechanical injury to roots, trunks, or branches. This can weaken a tree's resistance to a number of diseases and insect infestation. Trees should be clearly marked and given wide clearance. Excavation around trees should not be within the drip line of the tree.
- Soil compaction squeezes the air and water out of the soil making it difficult for a tree to absorb oxygen and water. No construction equipment should be allowed to run over the roots within the drip line of the tree.
- Grading practices that deposit soil over the roots of trees eventually suffocates those roots. More than an inch or two of soil over the roots is enough to potentially suffocate the roots of trees and compromise the health of the tree. Measures can be taken to improve soil aeration around tree roots if it is necessary to add fill within the critical root zone (see Figure 6-1).
- Grading practices that divert too much runoff to a mature stand of trees can result in damage. As a tree matures its ability to adapt to changes decreases. Additionally, if a stand of trees is located in a normally dry area that suddenly becomes very wet, the additional water may kill the trees. An arborist should be consulted these situations to determine the trees' tolerance to a change in hydrology.
- A tree protection plan with written recommendations for the health and long-term welfare of the trees during the pre-construction, demolition, construction, and post-construction development phases, should be developed. The tree protection plan should include specifics about avoiding injury, information about treatment for damage and specifics about required inspections of protected trees. The tree protection plan should also provide information about caring for damaged trees.

4.2.5 Construction Sequencing

Construction sequencing is important to avoid problems while constructing LID projects. Proper sequencing decreases the likelihood of damage to the BMP during construction and helps to ensure optimal performance of each IMP. Each LID practice is somewhat different, therefore information should be provided to the contractor on the proper sequencing. The construction drawings should clearly state the designer's intentions and an appropriate sequence of construction should be shown on the plans. This sequence should then be the topic of a detailed discussion at the pre-construction meeting (that must include the on-site responsible construction personnel) and then enforced by an appropriate inspection program throughout the construction period.

Conservation areas must be identified and protected before any major site grading takes place. Most of the engineered LID practices (bioretention, infiltration trenches, and infiltration swales) should be constructed at the end of the site development process, and preferably when most of the site is stabilized. Any LID practice that relies on filtration or infiltration must be protected throughout the construction phase from sedimentation and should not be activated until the contributing drainage area is stabilized. For example, bioretention systems should be constructed at the time of final grading and landscaping, and/or these areas should be protected from sedimentation until the drainage routes to the facility are stabilized.

4.2.6 Maintenance

As with any stormwater management technique, maintenance is essential with LID BMPs to ensure that the designed stormwater benefits continue. Post-construction inspections and maintenance are important to

ensure that each technique is functioning effectively. Annual inspections are recommended, with more frequent inspections during the first year to ensure that vegetation is thriving.

Inspection and maintenance of structural LID practices such as cisterns, vegetated roofs, permeable pavements, infiltration structures, and manufactured proprietary devices should follow state or local stormwater minimum standards, as well as manufacturer's recommendations for maintenance or repair. Any under-drains or outfall structures should be inspected on a regular basis and cleaned out or repaired as necessary. The primary maintenance requirement for vegetative LID structural and non-structural practices is inspection and periodic repair or replacement of the treatment area's components. This often includes the maintenance of the vegetative cover (pruning), replacing mulch, removing weeds, and possibly removing sediment to preserve the practice's hydraulic properties. For many LID practices, this generally involves little more than the routine periodic landscape type maintenance. Maintenance requirements are further discussed above in sections associated with specific LID technique.

To ensure continued long-term maintenance, all affected landowners should be made aware of their individual or collective maintenance responsibilities through legal instruments such as maintenance agreements and maintenance easements that convey with the property. Outreach materials, such as LID brochures or facts sheets that explain the function of practices and the anticipated maintenance responsibilities for homeowners, should be included in settlement or homeowner association documents. The developer should prepare a maintenance plan that provides clear guidance and instructions to the property owner property manager or property owners association about the annual maintenance needs of each LID technique.

Appendix B

Harris County Standard Operating Procedure for Determining In Situ Hydraulic Performance of High Flow Rate Bioretention Media

Objective

Provide as-built confirmation of proper installation and hydraulic performance, to meet Harris County minimum 30"/hour Infiltration rate requirements, of bioretention media on newly-placed bioretention systems. This procedure measures the entire media profile under saturated conditions to insure a reliable and accurate result.

Example Site Test Layout and Design Schematic

For bioretention systems with a surface area less than 50 m² (538 ft²), in situ hydraulic testing should be conducted at three points that are spatially distributed. For systems with a surface area greater than 50 m², an extra monitoring point should be added for every additional 100 m² (1076 ft²). (Values are based on recommendations from the Facility for Advancing Water Biofiltration.)

Testing should be performed on the perimeter since this is the area most likely to be impacted by sediment in the runoff.

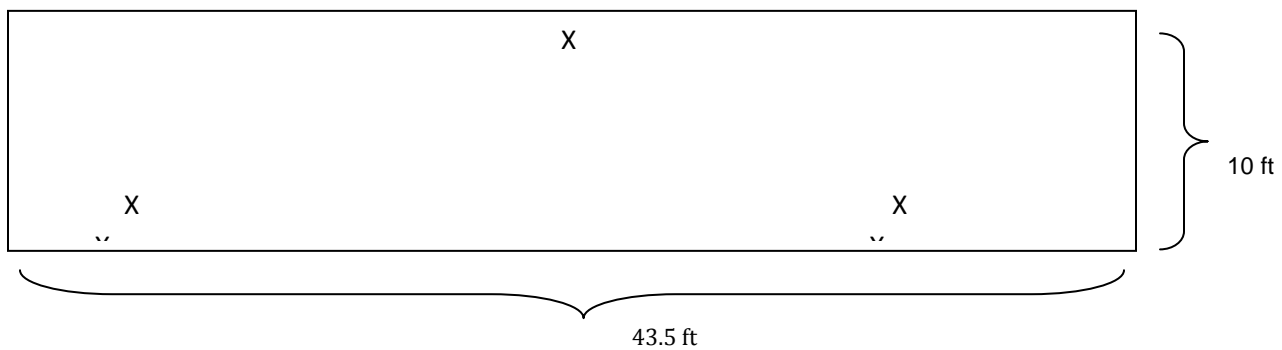


Figure 1. Site Layout

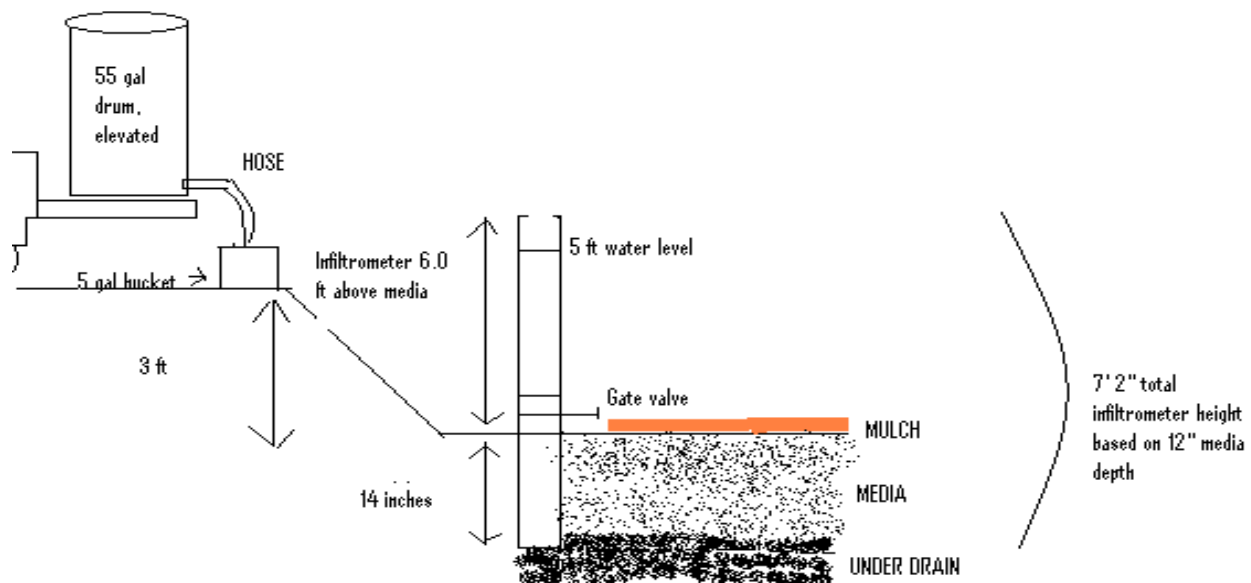


Figure 2. Example Design Schematic

Equipment Description

The components of this test apparatus are readily accessible, inexpensive and lightweight.

Infiltrometer Components:

- X inches long x 6 inch ID schedule 40 white PVC pipe with 2 inch beveled ending and 2 opposite holes drilled one inch from top sized for rebar
- ($X = \text{media depth} + 2 \text{ inch pipe into UD} + 3 \text{ inch pipe above media}$; ex: for a 12 inch media depth you would need 17 inch pipe)
- 24 inch piece of rebar for insertion through 2 drilled holes for removal of pipe from media after test
- 5 ft long x 6 inch ID schedule 40 clear PVC cylinder
- 6 inch gate valve with pull handle designed to fit schedule 40 PVC
- Tube of silicone caulking

Hammering Components:

- 4 inch thick by 8 inch wide by 24 inch long pressure treated wood board
- 5# to 10# sledge hammer

Water Storage Components:

- 5 gallon clear graduated bucket (in gallons)
- Two 55 gallon sealed plastic drums with the following:
 - at least 1 bung hole (screw cap in lid) to prevent air lock in each drum
 - plastic barb with gasket placed at bottom of each drum for water discharge
 - plastic shut off valve placed at end of hose to control flow at test location
 - garden hose connector attached to barb in drums to control flow and connect hose
 - garden hose with screw-on shut off valve at flow end
- An acceptable alternative to this is a simple low-cost water supply system.

Other Materials

- Water
- Manhole lifter or crow bar for use on rebar to remove pipe from media after test completion
- Light weight oil or petroleum jelly with dry wipes for application
- Level
- Stopwatch
- Rake/shovel
- Measuring tape
- Large stones (~2 inch; see Figure 6)
- Flashlight
- Clipboard with pencil and Table 1 from this document

Assembly:

Insert 5 ft long x 6 inch clear PVC cylinder into topside opening of gate valve. Apply silicone caulking to outside area where cylinder and gate valve meet. Smooth out caulking to create leak proof seal. Let dry according to directions on tube.

Test Methodology

1. Carefully scrape away any surface covering (e.g. mulch, gravel, leaves) without disturbing the soil filter media surface.

2. In an area near the test location, confirm media profile depth by using a shovel to dig to under drain stone and place measuring tape in hole to determine depth from top of under drain stone to top of media bed. A flash light may be needed to ensure the under drain stone has been reached before a depth measurement is taken.
3. At the test location which has been cleared of mulch, locate the six (6) inch wide white PVC pipe (beveled end down) on the surface of the media. Ensure testing is not too close to vegetation. Place the wooden board over the pipe and then gently pound with the sledge hammer on top of the board (Figure 3). Hammer the PVC pipe into the entire media profile based on the depth previously determined until it is approximately 3 inches above the media (Figure 4). Check with level to insure that the pipe is plumb. Note: It is important that the pipe is driven in slowly and carefully to minimize disturbance of the filter media profile. The media may slightly move downward in the pipe during hammering, but not more than 1 inch, and will not significantly affect hydraulic performance.



Figure 3: Hammer pipe into media



Figure 4: Pipe installed in media

4. If top of pipe is less than 3 inches from media surface, remove media around outside of pipe so that the pipe is 3 inches from the media bed. This will allow the gate valve coupling to properly slide onto the pipe.
5. Remove board and rub lightweight oil/petroleum jelly on outside of PVC pipe above media (Figure 5).
6. Place 2 inch dissipater stones into pipe (Figure 6).



Figure 5. Oil application



Figure 6. Dissipater stones

7. Slide gate valve with clear PVC cylinder down onto the media PVC pipe (Figure 7). Note: Disregard black coupling on clear pipe as well as pipe plug in Figure 7.

8. Measure from the original surface of the media within the column to the 1ft, 2 ft, 3 ft, 4 ft and 5 ft gradations, and mark them on the clear PVC cylinder (Figure 8). The 1 ft and 5 ft marks are the critical marks, since the timed fall of the water level between these two intervals represent the pass/fail criteria for the test. (The time at other intervals between 1ft and 5 ft may be recorded for additional information, but will not be used in the pass/fail criteria).



Figure 7. Infiltrometer placement



Figure 8. Gradation of clear pipe

9. Fill a 5 gallon bucket with 3 gallons from the filled 55 gallon drum. Leave cap off of drum at test site to prevent airlock. Alternative water supply sources are acceptable.
10. Ensure the gate valve to the infiltrometer is closed. Fill with the 3 gallons of water (Figure 9). To create a saturated condition, an initial wetting of the media using the infiltrometer is conducted by opening up the gate valve completely. The gate valve should be slowly opened by tapping gently on the handle to prevent, a sudden high flow of water which might disturbance of the media surface by. Pulling open by hand tends to force the valve open too quickly.



Figure 9. Filling infiltrometer with water

11. After the water level disappears from the clear column, a drain down time of 25 minutes is allowed to ensure free water has drained from the system. The media is now at field capacity (fully saturated).
12. After 25 minutes, ensure the gate valve is closed. Fill the 5 gallon bucket with water and continue to fill the column until water level reaches the very top of the clear pipe. Water is then re-introduced by opening the gate valve slowly by tapping the handle gently. The stopwatch should be started when the falling water level reaches the 5 ft gradation, and recorded subsequently at every 1 ft gradation. The stopwatch time must be stopped when the water level reaches the 1 ft mark.
13. Pass/fail criteria is based on maximum drawdown times (Table 1), relative to media depth. For example, a media profile depth of 18 inches should not exceed a drawdown time of 27 minutes and 0 seconds between the 5 ft and 1 ft gradations.

Table 1. Maximum Time Criteria Based on Media Depth

Media Depth (inches)	Maximum Drawdown Time (min:sec)
6	8:00
7	9:48
8	11:30
9	13:18
10	15:00
11	16:42
12	18:18
13	19:54
14	21:24
15	22:54
16	24:18
17	25:42
18	27:00
19	28:18
20	29:30
21	30:42
22	31:54
23	33:00
24	34:06
25	35:12
26	36:12
27	37:12
28	38:12
29	39:06
30	40:00
31	40:54
32	41:42
33	42:30
34	43:24

35	44:06
36	44:54
37	45:36
38	46:18
39	47:00
40	47:42
41	48:24
42	49:00
43	49:36
44	50:12
45	50:48
46	51:24
47	52:00
48	52:30

Appendix C Maintenance Declaration

MAINTENANCE DECLARATION

Low Impact Development & Green Infrastructure Design Criteria for Storm Water Management

This Maintenance Declaration (this "Declaration") is made as of the ___ day of _____, 20___, by _____ **[INSERT NAME OF OWNER OF PROPERTY COVERED BY APPLICABLE PLAT]** _____ ("Owner").

RECITALS

- A. Owner is a _____ **[INSERT TYPE OF ENTITY]** _____ and has the legal authority to construct {water, sewer, and drainage facilities, road facilities and related road improvements, and recreational and landscaping improvements} (Specify those that apply) within the Property (hereinafter defined). .
- B. Owner owns that certain real property described on **Exhibit A** attached to this Declaration and incorporated herein for all purposes (the "Property").
- C. In accordance with the Low Impact Development & Green Infrastructure Design Criteria for Storm Water Management (the "LID Criteria"), certain enhancements to public improvements are required. Owner intends to submit to Harris County, Texas (the "County") for approval a plat covering the Property (the "Plat"), which, among other things, includes enhancements to certain public improvements to be constructed within the Plat boundaries pursuant to the LID Criteria as are identified below (collectively, the "Enhancements").
- D. Owner desires to declare its obligation to construct and maintain the Enhancements.

NOW, THEREFORE, Owner hereby declares that, upon acceptance of the Plat by the County and construction of the Enhancements, Owner will be responsible for all maintenance for the following Enhancements [*check as applicable*]:

- Drainage, including ditches, swales and storm sewers
- Storm water quality and drainage features, including green infrastructure and low impact development practices
- Water and sanitary sewer lines
- Upgraded crosswalks and intersections
- Pedestrian underpasses and overpasses
- Conduit
- Recreational improvements

- Enhanced landscaping
- Lighting improvements (excluding traffic signals)
- Other _____

- Other _____

- Other _____

This Declaration shall be governed by, construed and interpreted in accordance with, and enforceable under, the laws of the State of Texas.

IN WITNESS WHEREOF, Owner has caused this Declaration to be executed as of the date and year first set forth above.

[INSERT NAME OF OWNER]

(name and title of Owner's representative)

ATTEST:

(add in if appropriate)

Add standard notary acknowledgement

Attachment:

Exhibit A - Description of Property

After recording, return to: *[insert Owner's address]*

Appendix D References

USGA Recommendations for a Method of Putting Green Construction, 2004 USGA
WSUD Engineering Procedures: Stormwater, 2005, Melbourne Water
Stormwater Management Guidance Manual Version 2.0, City of Philadelphia
Low Impact Development Guidance Manual, City of Wilmington, North Carolina
Town of Huntersville Water Quality Design Manual, 2008, Mecklenburg County Water Quality Program
Low Impact Development Technical Guidance Manual for Puget Sound, 2005, Puget Sound Action Team & Washington State University Pierce County Extension
Seattle Right of Way Improvements Manual, City of Seattle
Bioretention.com website
Low Impact Development Handbook, 2007, County of San Diego
Low Impact Development Center, Inc. website
San Mateo County Sustainable Green Streets and Parking Lots Design Guidebook, 2009 San Mateo County
HCFCD, 2010. HCFCD Storm Water Management Program (SWMP). TPDES Permit No. WQ0004685000. Revised October 31, 2010.
HCFCD, 2010. HCFCD Policy, Criteria, & Procedure Manual. Revised December 2010.
HCPID, 2010. HCPID Storm Water Management Program (SWMP). TPDES Permit No. WQ0004685000. Revised October 31, 2010.

Appendix E Resources

San Mateo County Sustainable Green Streets and Parking Lots Design Guidebook, First Edition, January 2009 (http://www.flowstobay.org/ms_sustainable_guidebook.php)

The Low Impact Development Center, Inc. (<http://www.lowimpactdevelopment.org>)

Low Impact Development Urban Design Tools Website (<http://www.lid-stormwater.net/index.html>)

Runoff Reduction Method, Virginia Department of Conservation & Recreation
(<http://www.princegeorgescountymd.gov/Government/AgencyIndex/DER/ESG/manuals.asp>)

USGA Recommendations for a Method of Putting Green Construction
([http://www.usga.org/course_care/articles/construction/greens/USGA-Recommendations-For-A-Method-Of-Putting-Green-Construction\(2\)/](http://www.usga.org/course_care/articles/construction/greens/USGA-Recommendations-For-A-Method-Of-Putting-Green-Construction(2)/))

WSUD Water Sensitive Urban Design Program (<http://www.wsud.org>)

WSUD Engineering Procedures: Stormwater, 2005, Melbourne Water
(<http://wsud.melbournewater.com.au/>)

Stormwater Management Guidance Manual Version 2.0, City of Philadelphia
(<http://www.phillyriverinfo.org/WICLibrary/PSMGM%20V2.0.pdf>)

Low Impact Development Guidance Manual, City of Wilmington, North Carolina
(<http://www.nhcgov.com/planningandinspections/Documents/LID%20Manual.pdf>)

Town of Huntersville Water Quality Design Manual, 2008, Mecklenburg County Water Quality Program
(<http://www.huntersville.org/Planning%20Info/Huntersville%20Design%20Manual%20January%201,%202008%20Version.pdf>)

Low Impact Development Technical Guidance Manual for Puget Sound, 2005, Puget Sound
(http://www.psparchives.com/publications/our_work/stormwater/lid/LID_manual2005.pdf)

Seattle Right of Way Improvements Manual, City of Seattle
(http://www.seattle.gov/util/About_SPU/Drainage_&_Sewer_System/GreenStormwaterInfrastructure/index.htm)

Bioretention.com website (<http://www.bioretention.com>)

Low Impact Development Handbook, 2007, County of San Diego (<http://www.co.san-diego.ca.us/dplu/docs/LID-Handbook.pdf>)

Appendix F Acknowledgments

This Guide represents a commitment by Harris County “to enhance, enable and integrate sustainable use of land and water for our area’s continued growth and economic vitality.” This is in fact the mission statement of the Houston Land/Water Sustainability Forum, in which both Harris County Public Infrastructure Division and Harris County Flood Control have played a significant role since the it’s inception.

The direct impetus for the LID & Green Infrastructure Design Guide was the success of a Forum-sponsored Low Impact Development Design Competition, in which a broad range of participants from the local design community were asked to create a project design using these practices, in one of three categories: Green Roadway, Suburban Residential and Urban Redevelopment. The projects were real, in fact one was an existing Harris County road slated for expansion, and the data on which the designs were based was the same information any owner would have provided to a design team.

The results of the competition were twofold. First, there was a profound recognition by the participants of the value, validity and benefits for all parties in widespread adaptation and adoption of these practices. Second, was a groundswell of interest in getting new projects which utilize them permitted smoothly and without the delays which might otherwise accrue to permitting a new style of development which take such fundamentally different approach than the traditional development for which current rules and regulations were designed.

Rewriting regulations can be a time consuming process. Recognizing that taking advantage of the enthusiasm for adopting these practices, which have proven so beneficial elsewhere, and moving forward with LID-based projects meant removing the obstacles to permitting them. During the summer of 2010, under the auspices of the Houston Land/Water Sustainability Forum, a series of three day-long collaborative workshops were held specifically to examine the obstacles to permitting LID-based projects, exploring how LID practices could be adapted to meet the intent of current rules and developing guidelines for the permitting process. This process examined the primary development categories of Suburban Residential, Green Roads, Commercial and General Site Design, as well as Urban Infill and Redevelopment.

Participants in this process included key permitting, storm water, and development regulatory staffers, and leadership, from Harris County Public Infrastructure Division, Harris County Flood Control and the City of Houston. The design community was represented by the firms whose teams placed in the finals of the design competition and included civil and transportation engineers, planners, landscape architects and architects. Representatives from the Houston Council of Engineering Companies, the American Society of Landscape Architects and American Association of Civil Engineers and developers associated with the Greater Houston Builders Association also contributed.

Appendix G Acronyms

BMP	Best Management Practice
EPA	Environmental Protection Agency
GI	Green Infrastructure
HCFC	Harris County Flood Control District
HCPID-AED	Harris County Public Infrastructure Department Architecture & Engineering Division
HOA	Homeowners Association
IMP	Integrated Management Practice
LID	Low Impact Development
MTFP ROW	Major Thoroughfare and Freeway Plan Right Of Way
MUD	Municipal Utility District
PCPM	Policy Criteria and Procedures Manual (HCFC)
Q	Peak Discharge
Q _{allocated}	Allocated Discharge
Q _{exist}	Existing Discharge
Q _{prop}	Proposed Discharge
ROW	Right Of Way
SWPPP	Storm Water Pollution Prevention Plan
SWQ	Storm Water Quality
SWQMP	Storm Water Quality Management Plan
T _c	Time of Concentration
TC&R	Time of Concentration and Storage Coefficient (from HCFC PCPM)
TCEQ	Texas Commission on Environmental Quality
USGA	United States Golf Association
WQ _v	Water Quality Volume