STORMWATER PLANNING & LOW IMPACT DESIGN GUIDE

City of MURFREESBORO TENNESSEE

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Section 1.1 Stormwater Site Planning

1.1.1 Overview

1.1.1.1 Introduction

In order to most effectively and efficiently manage stormwater on new development and redevelopment sites, consideration of stormwater runoff needs to be fully integrated into the site planning and design process. This involves a more comprehensive approach to site planning and a thorough understanding of the physical characteristics and natural resources of the site. In addition, the management of the quantity and the quality of stormwater should be addressed in an integrated approach. The purpose of this manual is to provide design guidance and a framework for incorporating effective and environmentally sensitive stormwater management into the site development process and to encourage a greater uniformity in developing plans for stormwater management systems that meet the following goals:

- Control conveyance of runoff within and from the site to minimize flood risk to people and properties;
- Regulate discharge from the site to minimize downstream bank and channel erosion; and
    - Reduce pollutants in stormwater runoff to protect water quality;
    - When designing the stormwater management system for a site, a number of questions need to be answered by the site planners and design engineers, including:
        - How can the stormwater management system be designed to most effectively address the quality of runoff from the site, protect against increased streambank erosion, and meet flood control objectives?
        - What are the opportunities for utilizing site design practices to minimize the need for and the size of structural stormwater controls?
        - What are the development site constraints that preclude the use of certain structural controls?
        - What structural controls are most suitable and cost-effective for the site?

1.1.1.2 Five (5) Principles of Stormwater Management Site Planning

The following Five (5) Principles of Stormwater Management Site Planning should be kept in mind in preparing a Stormwater Management Site Plan for a development or redevelopment site:

1. **The site design should utilize an integrated approach to deal with stormwater quality protection, streambank protection, and flood control requirements.**

   The stormwater management infrastructure for a site should be designed to integrate drainage and flood control, water quality protection, and downstream streambank protection. Site design should be done in unison with the design and layout of stormwater infrastructure to better attain stormwater management goals. Together, the combination of site design practices and effective infrastructure layout and design can mitigate the worst stormwater impacts of most urban developments while preserving stream integrity and aesthetic attractiveness.

2. **Stormwater management practices should strive to utilize the natural drainage system and require as little maintenance as possible.**

   Almost all sites contain natural features which can be used to help manage and mitigate runoff from development. Features on a development site might include natural drainage patterns, depressions, permeable soils, wetlands, floodplains, and undisturbed vegetated areas that can be used to reduce runoff; provide infiltration, and stormwater filtering of pollutants and sediment; recycle nutrients; and maximize on-site storage of stormwater.

   Site design should seek to supplement the effectiveness of natural systems rather than to ignore or replace them. Further, natural systems typically require low or no maintenance, and will continue to function many years into the future.

3. **Structural stormwater controls should be implemented only after all site design and nonstructural options have been exhausted.**

   Operationally, economically, and aesthetically, stormwater sensitive site design and the use of natural techniques offer significant benefits over structural stormwater controls. Therefore, all opportunities for utilizing these methods should be explored before implementing structural stormwater controls such as wet ponds.

4. **Structural stormwater solutions should attempt to be multi-purpose and be aesthetically integrated into a site's design.**

   A structural stormwater facility need not be an afterthought or ugly nuisance on a development site. A parking lot, soccer field, or city plaza can serve as a temporary storage facility for stormwater. In addition, water features such as ponds and lakes, when correctly designed and integrated into a site, can increase the aesthetic value of a development.

5. **"One size does not fit all" in terms of stormwater management solutions.**

   Although the basic problems of stormwater runoff and the need for its management remain the same, each site, project, and watershed presents different challenges and opportunities. For instance, an infill development in a highly urbanized town center or downtown area will require a much different set of stormwater management solutions than a low-density residential subdivision in a largely undeveloped watershed. Therefore, local stormwater management needs to take into account differences between development sites, different types of development and land use, various watershed conditions and priorities, the nature of downstream lands and waters, and community desires and preferences.

1.1.2 Stormwater Management Site Plans

1.1.2.1 Applicability

Stormwater Management Site Planning is applicable to land disturbing activity of 1 acre or more where total impervious area is increased by more than 5% above the current land development conditions. The

New development or redevelopment in critical or sensitive areas, or as identified through a watershed study or plan, may be subject to additional performance and/or regulatory criteria. Furthermore, these sites may need to utilize or restrict certain structural controls in order to protect a special resource or address certain water quality or drainage problems identified for a drainage area.

1.1.2.2 Contents of an Stormwater Management Site Plan

The following elements are components of an acceptable Stormwater Management Site Plan. Projects may be requested to prepare a site plan that includes a defined subset of the elements outlined below.

1 **Existing Conditions Hydrologic Analysis**
2 **Project Description and Design Considerations**
3 **Post-Development Hydrologic Analysis**
4 **Stormwater Management System Design**
5 **Construction Stormwater Pollution Prevention Plan (SWPPP)**
6 **Landscaping Plan**
7 **Operations and Maintenance Plan**
8 **Evidence of Acquisition of Applicable Federal, State, and Local Permits**
9 **Waiver Requests**

The typical contents of each element are described in the following sections.

1.1.3 Developer Steps to Prepare a Stormwater Management Site Plan

1.1.3.1 Introduction

The stormwater management site plan should consist of site layout mapping, supporting design calculations, and plans that sufficiently represent the proposed stormwater management system (recommended scale of 1" = 50').

This section describes the typical contents and general procedure for preparing a Stormwater Management Site Plan. The level of detail involved in the plan will depend on the project size and the individual site and development characteristics.

The preparation of a Stormwater Management Site Plan follows these steps:

- Step 1 - Consider the Five (5) Principles of Stormwater Management Site Planning
- Step 2 – Review & Coordination with City of Murfreesboro Subdivision Design Requirements and Standard Street Specifications
- Step 3 - Perform Site Analysis and Inventory
- Step 4 - Prepare Conceptual Stormwater Management Site Plan
- Step 5 - Prepare Preliminary Stormwater Management Site Plan
- Step 6 - Complete Final Stormwater Management Site Plan

Worksheets are provided in Appendix C to assist with the development of the Stormwater Management Site Plan.

1.1.3.2 Step 1 - Consider the Five (5) Principles of Stormwater Management Site Planning

As discussed in a previous section, the following principles should be kept in mind during all steps of preparing a Stormwater Management Site Plan for a development site:

1. The site design should utilize an integrated approach to deal with stormwater quality protection, streambank protection and flood control requirements.
2. Stormwater management practices should strive to utilize the natural drainage system and require as little maintenance as possible.
3. Structural stormwater controls should be implemented only after all site design and nonstructural options have been exhausted.
4. Structural stormwater solutions should attempt to be multi-purpose and be aesthetically integrated into a site's design.
5. "One size does not fit all" in terms of stormwater management solutions.

1.1.3.3 Step 2 - Review of City of Murfreesboro Subdivision Design Requirements and Standard Street Specifications

The site developer should become familiar with these requirements and specifications. These requirements and specifications include, but are not limited to:

- Design storm frequencies
- Conveyance design criteria

- Floodplain criteria
- Buffer/setback criteria
- Wetland provisions
- Watershed-based criteria
- Need for physical site evaluations (infiltration tests, geotechnical evaluations, etc.)
- Grading plan

Current land use plans, comprehensive plans, zoning ordinances, road and utility plans, watershed or overlay districts, and public facility plans should all be consulted to determine the need for compliance with other local and state regulatory requirements.

1.1.3.4 Step 3 - Perform Site Analysis and Inventory

Using approved field and mapping techniques, the site engineer should collect and review information on the existing site conditions and map the following site features:

- Topography
- Drainage patterns and basins
- Intermittent and perennial streams
- Soils
- Ground cover and vegetation
- Existing development
- Existing stormwater facilities
- Adjacent areas
- Property lines and easements
- In addition, the site engineer should identify and map all previously unmapped natural features such as:
    1. Wetlands
    2. Critical habitat areas
    3. Boundaries of wooded areas
    4. Floodplain boundaries
    5. Steep slopes
    6. Required buffers
    7. Proposed stream crossing locations
    8. Other required protection areas (e.g., well setbacks)

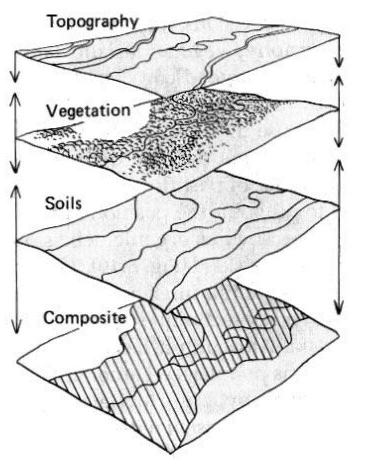


Figure 1.1.3-1
Composite Analysis
(Source: Marsh, 1983)

Other recommended site information to map or obtain includes utilities information, seasonal groundwater levels, and geologic data.

1.1.3.5 Step 4 - Prepare Conceptual Stormwater Management Site Plan

Based upon the review of existing conditions and site analysis, the design engineer should develop a Conceptual Stormwater Management Site Plan for the project.

During the concept plan stage the site designer will perform most of the layout of the site including the preliminary stormwater management system design and layout. The Conceptual Stormwater Management Site Plan allows the design engineer to propose a potential site layout and gives the developer and local review authority a “first look” at the stormwater management system for the proposed development. The Conceptual Stormwater Management Site Plan should be submitted to the local plan reviewer before detailed preliminary site plans are developed.

The following steps should be followed in developing the Conceptual Stormwater Management Site Plan with the help of the Worksheet for Conceptual Stormwater Management Site Plans found in Appendix C of this manual:

1. Use stormwater site design practices as applicable to develop the site layout, including:

- Preserving the natural feature conservation areas defined in the site analysis
- Fitting the development to the terrain and minimizing land disturbance
- Reducing impervious surface area through various techniques
- Preserving and utilizing the natural drainage system wherever possible
- Determine the water quality volume reduction if applicable, to be accounted for in the design of structural and non-structural stormwater controls on the site
- Calculate conceptual estimates of the design requirements for water quality protection, streambank protection, and flood control based on the conceptual plan site layout
- Perform screening and conceptual selection of appropriate structural stormwater controls and identification of potential siting locations

It is extremely important at this stage that stormwater design is integrated into the overall site design concept in order to best reduce the impacts of the development as well as provide for the most cost-effective and environmentally sensitive approach. Using hydrologic calculations, the goal of mimicking pre-development conditions can serve a useful purpose in planning the stormwater management system. For local review purposes, following the Checklist found in Appendix C of this manual, the Conceptual Stormwater Management Site Plan should include site layout mapping and plans (recommended scale of 1” = 50’), which illustrate at a minimum:

1. **Project Description**
   - Address and legal description of site
   - Vicinity map
   - Land use

2. **Existing conditions**:
   - Copy of applicable digital orthophotos showing proposed project boundaries
   - A topographic map of existing site conditions (no greater than a 2-foot contour interval recommended) with drainage basin boundaries indicated and project boundaries shown
   - Total size area (acres)
   - Total impervious area (square footage)
   - Benchmarks used for site control
   - Perennial and intermittent streams
   - Mapping of predominant soils from USDA soil surveys
   - Boundaries of existing predominant vegetation
   - Location and boundaries of other natural feature protection and conservation areas such as wetlands, lakes, ponds, floodplains, stream buffers and other setbacks (e.g., drinking water well setbacks, septic setbacks, etc.)
   - Location of existing roads, buildings, parking areas and other impervious surfaces
   - Existing utilities (e.g., water, sewer, gas, electric) and easements
   - Location of existing conveyance systems such as grass channels, swales, and storm drains
   - Flow paths
   - Location of floodplain/floodway limits and relationship of site to upstream and downstream properties and drainages
   - Location and dimensions of existing channels, bridges or culvert crossings

3. **Conceptual Site Layout**
   - Complete the Stormwater Management Conceptual Plan Worksheet
   - Hydrologic analysis to determine conceptual runoff rates, volumes, and velocities to support selection of Stormwater Controls
   - Identification and calculation of water quality volume reduction, if applicable
   - Conceptual estimates of the storm design approach requirements
   - Conceptual selection, location, and size of proposed structural stormwater controls
   - Conceptual limits of **proposed** clearing and grading
   - Total **proposed** impervious area (square footage)

4. Submit to local jurisdiction for review and comment

1.1.3.6 Step 5 - Prepare Preliminary Stormwater Management Site Plan

The Preliminary Stormwater Management Site Plan ensures that requirements and criteria are being complied with and opportunities are being taken to minimize adverse impacts from the development. This step builds upon the data developed in the Conceptual Stormwater Management Site Plan by refining and providing more detail to the concepts identified.

The Preliminary Stormwater Management Site Plan should consist of maps and supporting design calculations (hydrologic and hydraulic) for the proposed stormwater management system, and should include the following sections:

Existing Conditions Hydrologic Analysis

Provide an existing condition hydrologic analysis for stormwater runoff rates, volumes, and velocities, which includes:

- Existing conditions data developed in the Conceptual Stormwater Management Plan
- All existing stormwater conveyances and structural control facilities
- Direction of flow and exits from the site
- Analysis of runoff provided by off-site areas upstream of the project site
- Methodologies, assumptions, site parameters and supporting design calculations used in analyzing the existing conditions site hydrology

Project Description and Design Considerations

Provide an updated description of the project and the considerations and factors affecting the design approach that have changed between the conceptual and preliminary plans, including:

- A discussion of the water quality treatment techniques (pollution prevention practices) that are to be utilized on this site, if applicable
- A determination of groundwater recharge considerations, if applicable, for this site
- Identify hotspot land uses, if applicable, and how runoff will be addressed

Post-Development Hydrologic Analysis

Provide a post-development hydrologic analysis for stormwater runoff rates, volumes, and velocities, which includes:

- A topographic map of developed site conditions (minimum 2-foot contour interval) with the post-development basin boundaries indicated
- Total area of post-development impervious surfaces and other land cover areas for each subbasin affected by the project
- Runoff calculations for water quality volume and streambank protection for each subbasin
- Location and boundaries of proposed natural feature protection and conservation areas
- Documentation and calculations for any applicable water quality volume reduction methods being utilized
- Methodologies, assumptions, site parameters and supporting design calculations used in analyzing the post-development conditions site hydrology
- Supporting calculations for a downstream peak flow analysis to show safe passage of post-development design flows downstream. Document point downstream at which analysis ends, and how it was determined.

In calculating runoff volumes and discharge rates, consideration may need to be given to any planned future upstream land use changes. Depending on the site characteristics and given local design criteria, upstream lands may need to be modeled as “existing condition” or “projected buildout/future condition” when sizing and designing on-site conveyances and stormwater controls.

Stormwater Management System Design

Provide drawings and design calculations for the proposed stormwater management system, including:

- A drawing or sketch of the stormwater management system including the location of non-structural site design features and the placement of existing and proposed structural stormwater controls. This drawing should show design water surface elevations, storage volumes available from zero to maximum head, location of inlet and outlets, location of bypass and discharge systems, and all orifice/restrictor sizes.
- Narrative describing that appropriate and effective structural stormwater controls have been selected
- Cross-section and profile drawings and design details for each of the structural stormwater controls in the system. This should include supporting calculations to show that the facility is designed according to the applicable design criteria.
- Hydrologic and hydraulic analysis of the stormwater management system for all applicable design storms (should include stage-storage or outlet rating curves, and inflow and outflow hydrographs)
- Documentation and supporting calculations to show that the stormwater management system adequately meets the Design Approach (Section 1.2)
- Drawings, design calculations and elevations for all existing and proposed stormwater conveyance elements including stormwater drains, pipes, culverts, catch basins, channels, swales and areas of overland flow

The completed Preliminary Stormwater Management Site Plan should be submitted to the local review authority for review and comment.

1.1.3.7 Step 6 - Complete Final Stormwater Management Site Plan

The Final Stormwater Management Site Plan adds further detail to the Preliminary Stormwater Management Site Plan and reflects changes that are requested or required by the local review authority. The Final Stormwater Management Site Plan should include all of the revised elements of the Preliminary Stormwater Management Site Plan as well as the following items:

Construction Stormwater Pollution Prevention Plan (SWPPP)

- Sequence/phasing of construction and temporary stabilization measures
- Temporary structures that will be converted into permanent stormwater controls

Landscaping Plan

- Arrangement of planted areas, natural areas, and other landscaped features on the site plan
- Information necessary to construct the landscaping elements shown on the plan drawings
- Descriptions and standards for the methods, materials, and vegetation that are to be used in the construction

Operations and Maintenance Plan

- Description of maintenance tasks, frequency of maintenance, responsible parties for maintenance, funding, access, and safety issues
- Reviewed and approved maintenance agreements

Evidence of Acquisition of Applicable Federal, State, and Local Permits

Description and copies of any applicable federal, state, and/or local environmental permits such as USACE Regulatory Program permits, 401 water quality certification, or construction TPDES permits. Permits must be obtained prior to or in conjunction with final plan submittal, including:

- Notice of Intent (NOI) or Construction Site Notice, as appropriate,
- Permits obtained for any other stormwater related development requirements (i.e. USACE Regulatory Program permits, erosion control, grading, water rights permits, TDEC dam safety, etc.)

Waiver Requests

- Description of waiver requests

The completed Final Stormwater Management Site Plan should be submitted to the local review authority for final approval prior to any construction activities on the development site.

1.1.4 City of Murfreesboro Plan Review Responsibilities

1. Concept Plan Stage

Review of the Conceptual Stormwater Management Site Plan – During the concept plan stage the site designer will perform most of the layout of the site including the preliminary stormwater management system design and layout. The Conceptual Stormwater Management Site Plan allows the design engineer to propose a potential site layout and gives the developer and local review authority a "first look" at the stormwater management system for the proposed development. The Conceptual Stormwater Management Site Plan should be submitted to and approved by the Murfreesboro Water & Sewer Department (MWSD) and City of Murfreesboro Planning and Engineering Department before detailed preliminary site plans are developed.

It is in the Concept Plan Stage that the site developer is best able to integrate the stormwater design into the overall site design concept in order to reduce the impacts of the development, as well as provide for the most cost-effective and environmentally sensitive approach. This is done, in part, by evaluating and integrating as appropriate credits for the stormwater user fee and Water Quality Protection Volume reduction.

2. Preliminary Plan Stage

Review of Preliminary Site Plan

The Preliminary Stormwater Management Site Plan should consist of maps, narrative, and supporting design calculations (hydrologic and hydraulic) for the proposed stormwater management system, and should include the preliminary versions of the following Stormwater Management Site Plan components:

a. Existing Conditions Hydrologic Analysis
b. Post-Development Hydrologic Analysis
c. Stormwater Management System Design

A recommended checklist for the Preliminary Stormwater Management Site Plan Review is included in Appendix C of this Manual.

It should be demonstrated that appropriate and effective stormwater controls have been selected and adequately designed. The preliminary plan should also include, among other things, street and site layout, delineation of natural feature protection and conservation areas, soils data, existing and proposed topography, relation of site to upstream drainage, limits of clearing and grading, and proposed methods to manage and maintain conservation areas (e.g., easements, maintenance agreements/responsibilities, etc.)

3. Final Plan Stage

Review Final Stormwater Management Site Plan **- T**he Final Stormwater Management Site Plan should include all of the revised elements from the preliminary plan as well as the following remaining items:

a. Construction Stormwater Pollution Prevention Plan (SWPPP)
b. Landscaping Plan
c. Operations and Maintenance Plan

d. Evidence of Acquisition of Applicable Federal, State, and Local Permits
e. Waiver Requests

A recommended checklist for the Final Stormwater Management Site Plan Review is included in Appendix C of this Manual.

This process may be iterative. The reviewer should ensure that all submittal requirements have been satisfactorily addressed and permits, easements, and pertinent legal agreements (e.g., maintenance agreements, performance bond, etc.) have been obtained and/or executed.

The approved Final Stormwater Management Site Plan should be submitted during the platting development process to the local review authority for final approval. The Stormwater Management Site Plan must be approved prior to the preliminary plat approval and prior to any construction activities on the development site. Approval of the Final Stormwater Management Plan is the last major milestone in the stormwater planning process. The remaining steps are to ensure the plan is installed, implemented, and maintained properly.

1.1.5 City of Murfreesboro Responsibilities during Construction and Operation

After the Stormwater Management Site Plan and the final plat have been prepared and approved, the project will move into construction and the ongoing operation of related facilities and stormwater treatment areas.

1. Construction Inspections

Prior to any construction activities commencing a City of Murfreesboro Land Disturbance Permit shall be acquired. Additionally, a pre-construction meeting shall occur before any clearing or grading is initiated on the site. Natural feature protection areas and limits of disturbance shall be adequately staked and adequate erosion and sediment control measures shall be in place.

Project sites shall be periodically inspected during construction by the Murfreesboro Water & Sewer Department and City of Murfreesboro Planning and Engineering Dept. to ensure that conservation areas have been adequately protected and that stormwater control and conveyance facilities are being constructed as designed. Inspection frequency may vary with regard to site size and location; however, monthly inspections are a minimum. In addition, some inspections shall occur after larger storm events (e.g., 0.5 inches and greater to assure compliance with the Construction General Permit). Refer to Appendix A and Appendix B to the City of Murfreesboro's Pre-Construction Activity Inspection worksheet and Construction Activity Inspection worksheets.

Stop work orders shall be issued by the City of Murfreesboro Building and Codes Department in instances of non-compliance wit h the applicable City of Murfreesboro Ordinances.

A final inspection shall be performed to ensure that the construction conforms to the intent of the approved design. Prior to accepting the infrastructure components, issuing an occupancy permit, and releasing any applicable bonds, the City of Murfreesboro shall ensure that: (1) temporary erosion control measures have been removed; (2) stormwater controls are unobstructed and in good working order; (3) permanent vegetative cover has been established in exposed areas; (4) any damage to natural feature protection and conservation areas has been mitigated; (5) conservation areas and buffers have been adequately marked or signed; and (6) any other applicable conditions have been met.

Record drawings of the structural stormwater controls, drainage facilities, and other infrastructure components shall be supplied by the Developer or Developer's engineer for determining long-term maintenance activities for the site.

2. Ongoing Maintenance Inspections

Ongoing inspection and maintenance of a project site's stormwater management system shall occur from time to time by the City of Murfreesboro.

Preparation of maintenance plans shall be a requirement of the Stormwater Management Site Plan preparation and review process. A maintenance plan shall outline the scope of activities, schedule, costs, funding source, and responsible parties. Vegetation, sediment management, access, and safety issues should also be addressed. In addition, the plan sall address the testing and disposal of sediments that will likely be necessary and the ultimate replacement of structures as needed.

The City's goal is for annual inspections of stormwater management facilities to be conducted . Where chronic or severe problems exist, the City of Murfreesboro shall have the authority to remedy the situation and charge the responsible party for the cost of the work. This authority shall be a requirement in the City of Murfreesboro's Post-construction Stormwater Ordinance.

1.1.6 Stormwater Management Site Plan Design Tools

There are several design tools that can be used by the developer, planner, and engineer in the development of a Stormwater Management Site Plan for a specific project. The tools include the following, which are discussed in more detail in subsequent sections of this Manual:

- Planning and Design Approach for Stormwater User Fee Credit (Section 1.2)
    - Design requirements to achieve water quality protection, streambank protection, and flood control goals
- Site Design Practices (Section 1.3)
    - Nonstructural approaches to be used during site planning
- Stormwater Controls (Section 1.4)
    - Controls to remove pollutants, regulate discharge, and/or convey stormwater

Section 1.2 Planning and Design Approach for Stormwater User Fee Credit

1.2.1 Introduction

This section presents an integrated approach for meeting the stormwater runoff quality and quantity management goals by addressing the key adverse impacts of development on stormwater runoff. The purpose is to provide guidance for designing a comprehensive stormwater management system as part of the Stormwater Management Site Plan to:

- Remove pollutants in stormwater runoff to protect water quality;
- Regulate discharge from the site to minimize downstream bank and channel erosion; and
- Control conveyance of runoff within and from the site to minimize flood risk to people and property.

The Design Approach is a coordinated set of design standards that allow the site engineer to design and size stormwater controls to address these goals. Each of the Design Steps should be used in conjunction with the others to address the overall stormwater impacts from a development site. When used as a set, the Design Approach controls the entire range of hydrologic events, from the smallest runoff-producing rainfalls up to the 100-year, 24-hour storm.

The design approach for each of the goals above is summarized in Table 1.2-1 below:

Table 1.2-1 Steps for Design Approach for Stormwater Control and Impact Mitigation

Steps	Approach
Step 1: Water Quality Protection	Achieved using one or a combination of the following options: (1) Conserve natural features, reduce impervious cover, and use the natural drainage system by applying the Site Design Practices; (2) Determine the Water Quality Protection Volume (WQ_V), provide stormwater pollution prevention by reducing total suspended solids from the development site for runoff resulting from rainfalls of up to 1.2 inches (85^{th} percentile storm);
Step 2: Streambank Protection	Provide streambank protection from erosion due to increased stormwater volumes and velocities caused by development using one of the following options: (1) Provide on-site controlled release of the 3.1" storm event over a period of 24 hours (Streambank Protection Volume, SP_V).
Step 3: Flood Control	Onsite: Minimize localized site flooding of streets, sidewalks, and properties by a combination of on-site stormwater controls and conveyance systems. These systems will be designed for the "Streambank Protection" and "Conveyance" storm event frequencies. Depending upon their location, function, and the requirements of the local jurisdiction, the full build-out 100year storm event is to be conveyed on-site such that no resulting habitable structural flooding occurs. Downstream: Based on the downstream assessment, manage downstream flood impacts caused by the increase of stormwater discharges from the development using one of the following options: (1) Document acceptable downstream conditions; (2) Improve downstream conditions; (3) Maintain existing downstream conditions; (4) Maintain existing on-site conditions. Flood impact reduction may be achieved by a combination of on-site control, downstream protection, floodplain management, and/or other mitigation measures.

Table 1.2-1 Steps for Design Approach for Stormwater Control and Impact Mitigation

Figure 1.2-1 graphically illustrates the relative volume requirements of each of the Design Steps and demonstrates that the pieces typically overlay one another. If the downstream assessment for flood control indicated upstream detention was needed to limit the discharge from a development, the volume requirement to achieve the downstream flood control requirement could also contain the volume needed to provide for Streambank Protection and, if required, Water Quality Protection. The appropriate type of detention facility could be designed with outlet controls to address each of the steps of the Design Approach. Obviously, detention may not be required in all situations, but consideration of site design practices and stormwater controls that work together to meet all the requirements is what is important. The following sections describe the Design Approach in more detail.

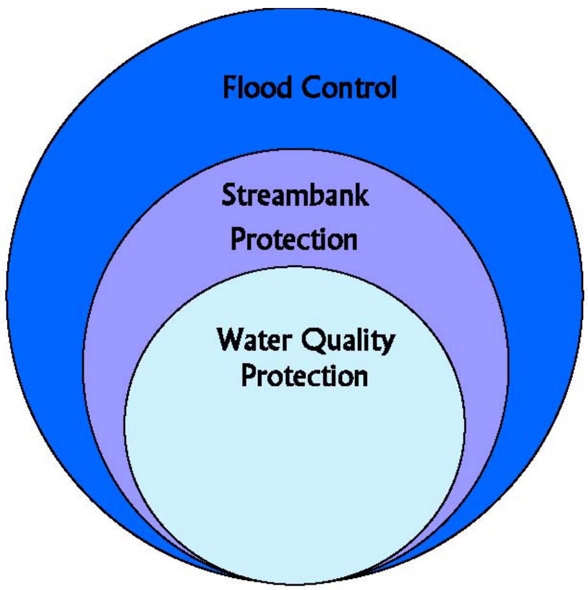


Figure 1.2-1 Representation of the *integrated* Design Approach

1.2.2 Water Quality Protection

The stormwater management site plan includes several alternatives that may be used in combination to protect the water quality of our streams, lakes, and rivers from the negative impacts of stormwater runoff. Listed below are three options by which a community can provide adequate water quality protection for development sites. The local jurisdiction should specify in their Local Criteria which of these options are acceptable, as well as any other alternatives for water quality protection.

Option 1: Use of Site Design Practices

Through the use of Site Design practices, as discussed in Section 1.3, natural drainage and treatment systems can be preserved. With conservation of natural features, reduced imperviousness, and the use of the natural drainage system, the generation of stormwater runoff and pollutants from the site is reduced.

Option 2: Water Quality Protection Volume

Using the Water Quality Protection Volume, stormwater runoff generated from sites can be treated using a variety of on-site structural and nonstructural techniques with the goal of removing a target percentage of the average annual total suspended solids.

A system has been developed by which the Water Quality Protection Volume is reduced, thus requiring less structural control. This is accomplished through the use of certain reduction methods, where affected areas can be deducted from the site area ("A") in the formula, thereby reducing the amount of runoff to be treated ("WQ_v"). For more information on the Water Quality Volume Reduction Methods see Section 1.2.3.2.

1.2.2.1 Water Quality Protection Volume

Hydrologic studies show smaller, frequently occurring storms account for the majority of rainfall events. Consequently, the runoff from the many smaller storms also accounts for a major portion of the annual pollutant loadings. By treating these frequently-occurring, smaller rainfall events and the initial portion of the stormwater runoff from larger events, it is possible to effectively mitigate the water quality impacts from a developed area.

Studies have shown the 85^{th} percentile storm event (i.e., the storm event that is greater than 85% of the storms that occur) is a reasonable target event to address the vast majority of smaller, pollutant-loaded storms. Based on a rainfall analysis, 1.2 inches of rainfall has been identified as the average depth corresponding to the 85^{th} percentile storm for the Middle Tennessee region. The runoff from these 1.2 inches of rainfall is referred to as the Water Quality Protection Volume (WQ_v). Thus, a stormwater management system designed for the WQ_v will treat the runoff from all storm events of 1.0 inches or less, as well as a portion of the runoff for all larger storm events. The Water Quality Protection Volume is directly related to the amount of impervious cover and is calculated using the formula below:

$$WQv = 1.2 * Rv * A / 12$$

where:

WQ_v = Water Quality Protection Volume (in acre-feet)

$R_v = 0.05 + 0.009(I)$ where I is percent impervious cover

A = site area in acres remaining after reduction

Determining the Water Quality Protection Volume (WQ_v)

- *Measuring Impervious Area*: The area of impervious cover can be taken directly off a set of plans or appropriate mapping. Where this is impractical, NRCS TR-55 land use/impervious cover relationships can be used to estimate impervious cover. I is expressed as a percent value not a fraction (e.g., I = 30 for 30% impervious cover)
- *Multiple Drainage Areas*: When a development project contains or is divided into multiple outfalls, WQ_v should be calculated and addressed separately for each outfall.
- *Water Quality Volume Reduction*: The use of certain site design practices may allow the WQ_v to be reduced. These volume reduction methods are described in Section 1.2.3.3.
- *Determining the Peak Discharge for the Water Quality Storm:* When designing off-line structural control facilities, the peak discharge of the water quality storm (Q_{wq}) can be determined using the method provided in Section 2.1.10.2.
- *Extended Detention of the Water Quality Volume:* The water quality treatment requirement can be met by providing a 24-hour drawdown of a portion of WQ_v in a stormwater pond or wetland system (as described in Chapter 5). Referred to as water quality ED (extended detention), it is different than providing extended detention of the 1-year storm for the streambank protection volume (SP_v). The ED portion of the WQ_v may be included when routing the SP_v.
- *Permanent Pool:* Wet ponds and wetlands will have permanent pools, the volume of which may be

used to account for up to 50% of the WQ_v.

- WQ_v can be expressed in cubic feet by multiplying by 43,560. WQ_v can also be expressed in watershed-inches by removing the area (A) and the "12" in the denominator.
- This approach to control pollution from stormwater runoff treats the WQ_v from a site to reduce a target percentage of post-development total suspended solids (TSS). TSS was chosen as the representative stormwater pollutant for measuring treatment effectiveness for several reasons:
- The measurement standard of using TSS as an "indicator" pollutant is well established.
- Suspended sediment and turbidity, as well as other pollutants of concern adhere to suspended solids, and are a major source of water quality impairment due to urban development in the region's watersheds.
- A large fraction of many other pollutants of concern are removed either along with TSS, or at rates proportional to the TSS removal.
- Even though TSS is a good indicator for many stormwater pollutants, there are special cases that warrant further consideration including:
- The removal performance for pollutants that are soluble or that cannot be removed by settling must be specifically designed for. For pollutants of specific concern, individual analyses of specific pollutant sources should be performed and the appropriate removal mechanisms implemented.
- Runoff, which is atypical in terms of normal TSS concentrations, will be treated to a higher or lesser degree. For example, treatment of highly turbid waters would attain a higher removal percentage but still may not attain acceptable water quality without additional controls or a higher level of BMP maintenance.
- Bed and bank-material sediment loads not accurately measured by the TSS standard are also typically removed using this approach.
- Site, stream, or watershed specific criteria, different from the TSS standard, may be developed through a state or federal regulatory program necessitating a tailored approach to pollution prevention.

1.2.2.2 Water Quality Volume Reduction Methods

A set of stormwater "volume reduction methods" is presented to provide developers and site designers an incentive to implement site designs that can reduce the volume of stormwater runoff and minimize the pollutant loads from a site. The reduction directly translates into cost savings to the developer by reducing the size of structural stormwater control and conveyance facilities.

The basic premise of the system is to recognize the water quality benefits of certain site design practices by allowing for a reduction in the water quality protection volume (WQ_v). If a developer incorporates one or more of the methods in the design of the site, the requirement for capture and treatment of the water quality protection volume will be reduced.

The methods by which the water quality volume can be reduced are listed in Table 1.2-2. Site-specific conditions will determine the applicability of each method. For example, the stream buffer reduction cannot be taken on upland sites that do not contain perennial or intermittent streams. Perennial streams flow 365 days a year in a normal year. Intermittent streams have short or lengthy periods of time when there is no flow in a normal year.

Table 1.2-2 Methods to Reduce the Water Quality Volume

Practice	Description
Natural area conservation	Undisturbed natural areas are conserved on a site, thereby retaining their pre-development hydrologic and water quality characteristics.
Stream buffers	Stormwater runoff is treated by directing sheet flow runoff through a naturally vegetated or forested buffer as overland flow.

Use of vegetated channels	Vegetated channels are used to provide stormwater treatment.
Overland flow filtration/infiltration zones	Overland flow filtration/infiltration zones are incorporated into the site design to receive runoff from rooftops and other small impervious areas.
Environmentally sensitive large lot subdivisions	A group of site design techniques are applied to low and very low density residential development.

Site designers are encouraged to use as many volume reduction methods as they can on a site. Greater reductions in stormwater storage volumes can be achieved when many methods are combined (e.g., disconnecting rooftops and protecting natural conservation areas). However, volume reduction cannot be claimed twice for an identical area of the site (e.g. claiming a reduction for stream buffers and disconnecting rooftops over the same site area).

Due to local safety codes, soil conditions, and topography, some of these volume reduction methods may be restricted. Designers are encouraged to consult with the appropriate approval authority to ensure if and when a reduction is applicable and to determine restrictions on non-structural strategies.

The methods by which the water quality volume can be reduced are detailed below. For each volume reduction method, there is a minimum set of criteria and requirements that identify the conditions or circumstances under which the reduction may be applied. The intent of the suggested numeric conditions (e.g., flow length, contributing area, etc.) is to avoid situations that could lead to a volume reduction being granted without the corresponding reduction in pollution attributable to an effective site design modification.

<u>Volume Reduction Method #1: Natural Area Conservation</u>

A water quality volume reduction can be taken when undisturbed natural areas are conserved on a site, thereby retaining their pre-development hydrologic and water quality characteristics. Under this method, a designer would be able to subtract the conservation areas from the total site area when computing the water quality protection volume. An added benefit is that the post-development peak discharges will be smaller, and hence, water quantity control volumes will be reduced due to lower post-development curve numbers or rational formula "C" values.

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

<u>Criteria:</u>

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

Example:

Residential Subdivision Area = 38 acres Natural Conservation Area = 7 acres Impervious Area = 13.8 acres

$R_v = 0.05 + 0.009 (I) = 0.05 + 0.009 (36.3\%) = 0.38$

Reduction:

7.0 acres in natural conservation area

New drainage area = 38 – 7 = 31 acres

Before reduction:
$WQ_v = (1.2)(0.38)(38)/12 = 1.81$ ac-ft

With reduction:
$WQ_v = (1.2)(0.38)(31)/12 = 1.47$ ac-ft

(19% reduction in water quality protection volume)

Volume Reduction Method #2: Stream Buffers

This reduction can be taken when a stream buffer effectively treats stormwater runoff. Effective treatment constitutes treating runoff through overland flow in a naturally vegetated or forested buffer. Under the proposed method, a designer would be able to subtract areas draining via overland flow to the buffer from total site area when computing water quality protection volume requirements. In addition, the volume of runoff draining to the buffer can be subtracted from the streambank protection volume. The design of the stream buffer treatment system must use appropriate methods for conveying flows above the annual recurrence (1-yr storm) event.

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

Criteria:

- The minimum undisturbed buffer width shall be 50 feet
- The maximum contributing length shall be 150 feet for pervious surfaces and 75 feet for impervious surfaces
- The average contributing slope shall be 3% maximum unless a flow spreader is used
- Runoff shall enter the buffer as overland sheet flow. A flow spreader can be installed to ensure this
- Buffers shall remain as naturally vegetated or forested areas and will require only routine debris removal or erosion repairs
- R_v is kept constant when calculating WQ_v
- Not applicable if overland flow filtration/groundwater recharge reduction is already being taken

Example:

Residential Subdivision Area = 38 acres Impervious Area = 13.8 acres Area Draining to Buffer = 5 acres

$R_v = 0.05 + 0.009 (I) = 0.05 + 0.009 (36.3\%) = 0.38$

Reduction:

5.0 acres draining to buffer

New drainage area = 38 – 5 = 33 acres *Before reduction*:
$WQ_v = (1.2)(0.38)(38)/12 = 1.81$ ac-ft

With reduction:
$WQ_v = (1.2)(0.38)(33)/12 = 1.57$ ac-ft

(13% reduction in water quality protection volume)

Volume Reduction Method #3: Enhanced Swales

This reduction may be taken when enhanced swales are used for water quality protection. Under the proposed method, a designer would be able to subtract the areas draining to an enhanced swale from total site area when computing water quality protection volume requirements. An enhanced swale can fully meet the water quality protection volume requirements for certain kinds of low-density residential development (see Volume Reduction Method #5). An added benefit is the post-development peak discharges will likely be lower due to a longer time of concentration for the site.

Rule: Subtract the areas draining to an enhanced swale from total site area when computing water quality protection volume requirements.

Criteria:

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

Example:

Residential Subdivision Area = 38 acres Impervious Area = 13.8 acres

R_v = 0.05 + 0.009 (I) = 0.05 + 0.009 (36.3%) = 0.38

Reduction:

12.5 acres meet enhanced swale criteria

New drainage area = 38 – 12.5 = 25.5 acres *Before reduction*:
WQ_v = (1.2)(0.38)(38)/12 = 1.81 ac-ft

With reduction:
WQ_v = (1.2)(0.38)(25.5)/12 = 1.21 ac-ft

(33% reduction in water quality protection volume)

Volume Reduction Method #4: Overland Flow Filtration/Groundwater Recharge Zones

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

Rule: If impervious areas are adequately disconnected, they can be deducted from total site area when computing the water quality protection volume requirements.

Criteria:

- Relatively permeable soils (hydrologic soil groups A and B) should be present
- Runoff shall not come from a designated hotspot
- The maximum contributing impervious flow path length shall be 75 feet
- Downspouts shall be at least 10 feet away from the nearest impervious surface to discourage "re-connections"
- The disconnection shall drain continuously through a vegetated channel, swale, or filter strip to the property line or structural stormwater control
- The length of the "disconnection" shall be equal to or greater than the contributing length
- The entire vegetative "disconnection" shall be on a slope less than or equal to 3 percent
- The surface imperviousness area to any one discharge location shall not exceed 5,000 square feet
- For those areas draining directly to a buffer, reduction can be obtained from either overland flow filtration *-or-* stream buffers (See Method #2)
- R_v is kept constant when calculating WQ_v

Example:

Site Area = 3.0 acres Impervious Area = 1.9 acres (or 63.3% impervious cover) "Disconnected" Impervious Area = 0.5 acres

R_v = 0.05 + 0.009 (I) = 0.05 + 0.009 (63.3%) = 0.62

Reduction:

0.5 acres of surface imperviousness hydrologically disconnected

New drainage area = 3 – 0.5 = 2.5 acres

Before reduction:

WQ_v = (1.2)(0.62)(3)/12 = 0.23 ac-ft

With reduction:
WQ_v = (1.2)(0.62)(2.5)/12 = 0.19 ac-ft

(17% reduction in water quality protection volume)

Volume Reduction Method #5: Environmentally Sensitive Large Lot Subdivisions

This reduction can be taken when a group of environmental site design techniques are applied to low and very low density residential development (e.g., 1 dwelling unit per 2 acres [du/ac] or lower). The use of this method can eliminate the need for structural stormwater controls to treat water quality protection volume requirements. This method is targeted towards large lot subdivisions and will likely have limited application.

Rule: Targeted towards large lot subdivisions (e.g. 2 acre lots and greater). The requirement for structural practices to treat the water quality protection volume shall be waived.

Criteria:

For Single Lot Development:

- Total site impervious cover is less than 15%
- Lot size shall be at least two acres
- Rooftop runoff is disconnected in accordance with the criteria in Method #4
- Grass channels are used to convey runoff versus curb and gutter

For Multiple Lots:

- Total impervious cover footprint shall be less than 15% of the area
- Lot areas should be at least 2 acres, unless clustering is implemented. Open space developments should have a minimum of 25% of the site protected as natural conservation areas and shall be at least a half-acre average individual lot size
- Grass channels should be used to convey runoff versus curb and gutter (see Method #3)
- Overland flow filtration/infiltration zones should be established (see Method #4)

1.2.3 Streambank Protection

The increase in the frequency and duration of bankfull flow conditions in stream channels due to urban development is the primary cause of accelerated streambank erosion and the widening and downcutting of stream channels. Therefore, a streambank protection criterion applies to all development sites for which there is an increase in the natural flows to downstream feeder streams, channels, ditches, and small streams.

The land developer may achieve streambank protection by either or both of the two primary methods below.

<u>Option 1: Streambank Protection Volume</u>

Another approach to streambank protection is to specify that 24 hours of extended detention be provided for runoff generated by the 1-year, 24-hour rainfall event to protect downstream channels. The required volume for extended detention is referred to as the Streambank Protection Volume (denoted SP_v). The reduction in the frequency and duration of bankfull flows through the controlled release provided by extended detention of the SP_v will reduce the bank scour rate and severity.

Determining the Streambank Protection Volume (SP_v)

- *SP_v Calculation Methods:* Several methods can be used to calculate the SP_v storage volume required for a site. Subsection 2.1.11 illustrates the recommended average outflow method for volume calculation.
- *Hydrograph Generation:* The SCS TR-55 hydrograph methods provided in Section 2.1.5 can be used to compute the runoff hydrograph for the 1-year, 24-hour storm.
- *Rainfall Depths:* The rainfall depth of the 1-year, 24-hour storm is considered 3.1 inches for the Murfreesboro Area.
- *Multiple Drainage Areas*: When a development project contains or is divided into multiple outfalls, SP_v should be calculated and addressed separately for each outfall.
- *Off-site Drainage Areas:* A structural stormwater control located "on-line" will need to safely bypass any off-site flows. Maintenance agreements may be required.
- *Routing/Storage Requirements:* The required storage volume for the SP_v must lie above the permanent pool elevation in stormwater ponds. Wet ponds and wetlands will have permanent pools. The portion of the WQ_v above the permanent pool may be included when routing the SP_v.
- Hydraulic control structures appropriate for each storage requirement may be needed.
- *Control Orifices*: Orifice diameters for SP_v control of less than 3 inches are not recommended without adequate clogging protection (see Section 4.6). Clogging protection must be provided on all orifices.

<u>Option 2: Determine Acceptable Downstream Conditions</u>

This option is available if a) the developer determines post-developed discharges and velocities for downstream watercourses, as described in Section 1.2.5, Downstream Assessment Guidelines; and b) velocities are less than recommended maximum velocities for the downstream watercourses; and c) supporting calculations and/or documentation shows, to the satisfaction of the Director of Engineering that stream integrity will not be compromised.

1.2.4 Flood Control

Flood control analyses are based on the following three (3) storm events. The storm frequencies for each event should be established in the Local Criteria section.

- *“Streambank Protection”:* Either the 1- year, 24-hour storm event
- *“Conveyance”*: Either the 5-, 10-, or 25-year, 24-hour storm event
- 100-year, 24-hour storm event

The intent of the flood control criteria is to provide for public safety; minimize on-site and downstream flood impacts from the “Streambank Protection”, “Conveyance”, and 100-year storm events; maintain the boundaries of the mapped 100-year floodplain; and protect the physical integrity of the on-site stormwater controls and the downstream stormwater and flood control facilities.

Flood control must be provided for on-site conveyance, as well as downstream outfalls as described in the following sections.

1.2.4.1 On-Site Conveyance

The “Conveyance” storm event is used to design standard levels of flood protection for streets, sidewalks, structures, and properties within the development. This is typically handled by a combination of conveyance systems including street and roadway gutters, inlets and drains, storm drain pipe systems, culverts, and open channels. Other stormwater controls may affect the design of these systems.

The design storms used to size the various on-site conveyance systems will vary depending upon their location and function. For example, open channels, culverts, and street rights-of way are generally designed for larger events (25- to 100-year storm), whereas inlets and storm drain pipes are designed for smaller events (5- to 25-year storm). These specific requirements should be referenced in the City of Murfreesboro’s Subdivision Design Requirements and Standard Street Specifications or consultation provided by the Murfreesboro Planning and Engineering Dept.

It is recommended that once the initial set of controls are selected in the Stormwater Management Site Plan design, the full build-out 100-year, 24-hour storm be routed through the on-site conveyance system and stormwater controls to determine the effects on the systems, adjacent property, and downstream areas. Even though the conveyance systems may be designed for smaller storm events, overall, the site should be designed appropriately to safely pass the resulting flows from the “full build-out” 100-year storm event with no flood waters entering habitable structures.

On-site flood control has many considerations for the safeguarding of people and property. On residential streets, for the “Conveyance” storm event, the safe passage of vehicular traffic is an important concern. For the 100-year storm events, traffic may be limited in order to utilize all or portions of the right-of-way for stormwater conveyance in order to protect properties. As such, the effective management of stormwater throughout the development for the full range of storm events is needed.

1.2.4.2 Downstream Flood Control

The downstream assessment is the first step in the process to determine if a specific development will have a flooding impact on downstream properties, structures, bridges, roadways, or other facilities. This assessment should be conducted downstream of a development to the point where the discharge from the proposed development no longer has a significant impact upon the receiving stream or storm drainage system.. Hydrologic and hydraulic evaluations must be conducted to determine if there are areas of concerns, i.e. an increase of the Base Flood Elevations. The City of Murfreesboro Planning and Engineering Department should be consulted to obtain records and maps related to the National Flood Insurance Program and the availability of Flood Insurance Studies and Flood Insurance Rate Maps

(FIRMs) which will be helpful in this assessment.
The downstream flood control criterion is based on an analysis of the "Streambank Protection" and "Conveyance" storm events, as well as the 100-year, 24-hour storm, (denoted Qp_{100}). The local jurisdiction should quantify the frequency of the "Streambank Protection" and "Conveyance" storm events, as well as other events that may be required based on site-specific conditions. Initially, the assessment will determine if the downstream receiving system has adequate capacity in its "full build-out" floodplain. To make this determination, Q_f, the runoff which the stream can handle without having an impact on downstream properties, structures, bridges, roadways, or other facilities, must be determined. There are four options by which a community can address downstream flood control.

Option 1: Acceptable Downstream Conditions

The developer shall provide all supporting calculations and/or documentation to show that the existing downstream conveyance system has capacity (Q_f) to safely pass the Q_{p100} discharge from the new development. Systems shown to be adequate are reflective of areas where attempts have been made to keep flood-susceptible development out of the "full build-out" floodplain through a combination of regulatory controls, stormwater master planning, and incentives. This includes communities that have regulated floodplains for fully-developed conditions. This approach recognizes that the impacts of new development might not be completely mitigated at the extreme flood level and provides a much greater assurance that local flooding will not be a problem because people and structures are kept out of harm's way.

Option 2: Downstream Improvements

If the downstream receiving system does not have adequate capacity, then the developer will be required to provide improvements to the off-site, downstream conveyance system. If this option is chosen the proposed improvements must be designed to adequately convey post-development stormwater peak discharges for the three (3) storm events. The improvements must also extend to the point at which the discharge from the proposed development no longer has a significant impact upon the receiving stream or storm drainage system. The developer must provide supporting calculations and/or documentation that the downstream peak discharges and water surface elevations are safely conveyed by the proposed system, without endangering downstream properties, structures, bridges, roadways, or other facilities.

Option 3: Maintain Existing Downstream Conditions

If the downstream receiving system does not have adequate capacity, then the developer shall provide stormwater controls to reduce downstream flood impacts. These controls include on-site controls such as detention, regional controls, and, as a last resort, local flood protection such as levees, floodwalls, floodproofing, etc. Stormwater master plans are a necessity to attempt to ensure public safety for the extreme storm event. The developer must provide supporting calculations and/or documentation that the controls will be designed and constructed so that there is no increase in downstream peak discharges or water surface elevations due to development.

Option 4: Maintain Existing On-Site Conditions

On-site controls shall be used to maintain existing peak discharges from the development site. The developer must provide supporting calculations and/or documentation that the on-site controls will be designed and constructed to maintain on-site existing conditions.
It is important to note that Option 4 does not require a downstream assessment. It is a detention-based approach to addressing downstream flood control after the application of the site design practices. For many developments however, the results of a downstream assessment may show that significantly less flood control is required than "detaining to pre-development conditions". This method may also exacerbate downstream flooding problems due to timing of flows. Therefore, it is strongly recommended that a downstream assessment be performed for all developments, and that Option 4 only be used when Options 1, 2, and 3 are not feasible.

The following items should be considered when providing downstream flood control.

- *Peak-Discharge and Hydrograph Generation:* Hydrograph methods can be used to compute the peak discharge rate and runoff for the three (3) storm events ("Streambank Protection", "Conveyance", and 100-year).
- *Rainfall Depths:* The rainfall depth of the three storm events can be determined from rainfall tables.
- *Off-site Drainage Areas:* Off-site drainage areas should be modeled as "full build-out" for the three storm events to ensure safe passage of future flows.
- *Downstream Assessment:* If flow is being detained on-site, downstream areas should be checked to ensure there is no peak flow or water surface increase above pre-development conditions to the point where the undetained discharge from the proposed development no longer has a significant impact upon the receiving stream or storm drainage system.

1.2.5 Downstream Assessment Guidelines

The City may waive the extended detention requirement for stream bank protection if the downstream impacts of the development have been evaluated and determined acceptable according to following criteria. The purpose of the assessment is to protect downstream properties from increased flooding and downstream channels from increased erosion.

The assessment should extend from the outfall/discharge point (or points) of a proposed development to a point downstream where the discharge from the proposed development no longer has a significant impact on the receiving stream or the storm drainage system. The assessment should be a part of the concept, preliminary and final stormwater plans, and should include the following properties:

- Hydrologic analysis of the pre- and post-development on-site conditions (see 1.2.6 below)
- Drainage path which defines the extent of the analysis
- Capacity analysis of all existing constraint points along the drainage path, such as existing floodplain developments, underground storm drainage systems, culverts, bridges, tributary confluences, or channels
- Off-site, undeveloped areas should be evaluated as if fully built out for both the pre- and post-development analyses
- Evaluation of peak discharges and velocities for three 24-hour rainfall events
    - Small frequency storm for streambank protection, either the one- or two-year rain event
    - A conveyance storm of either the 10 year or 25 year rainfall event
    - A 100 year storm event
- Separate analyses for each major outfall from the proposed development

Once the analysis is complete, the designer should ask these questions for each junction downstream:

- Are the post-development discharges greater than the pre-development discharges?
- Are the post-development velocities greater than the pre-development velocities?
- Are the post-development velocities greater than the velocities allowed for the downstream watercourses?

These questions should be answered for each of the three storm events. The answers will determine the necessity, type, and size of non-structural and structural controls to be placed on site or downstream of the proposed development.

1.2.6 Downstream Hydrologic Analysis

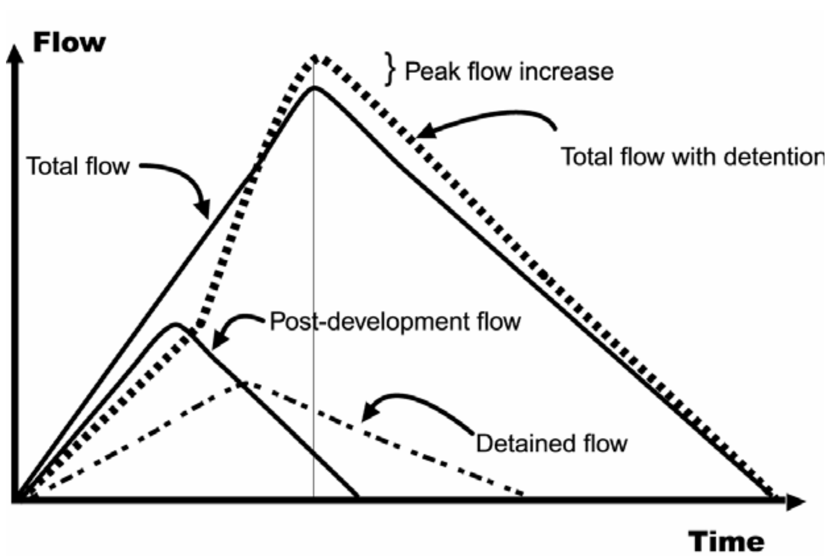
The purpose of the Streambank Protection and Flood Control criteria is to protect downstream properties from flood and erosion impacts due to upstream development. Some Local Criteria require the designer to control peak flow at the outlet of a site such that post-development peak discharge equals predevelopment peak discharge. It has been shown that in certain cases this does not always provide effective water quantity control downstream from the site and may actually exacerbate flooding problems downstream. The reasons for this have to do with (1) the timing of the flow peaks, and (2) the total increase in volume of runoff. Further, due to a site's location within a watershed, there may be very little reason for requiring flood control from a particular site. This section outlines a suggested procedure for determining the impacts of post-development storm water peak flows and volumes that a community may require as part of a developer's storm water management site plan.

1.2.6.1 Reasons for Downstream Problems

<u>Flow Timing</u>

If water quantity control (detention) structures are indiscriminately placed in a watershed and changes to the flow timing are not considered, the structural control may actually increase the peak discharge downstream. The reason for this may be seen in Figure 1.2.6.1a The peak flow from the site is reduced appropriately, but the timing of the flow is such that the combined detained peak flow (the larger dashed triangle) is actually higher than if no detention were required.

Figure 1.2.6.1a



In this case, the shifting of flows to a later time brought about by the detention pond actually makes the downstream flooding worse than if the post-development flows were not detained. This is most likely to happen if detention is placed on tributaries towards the bottom of the watershed, holding back peak flows and adding them as the peak from the upper reaches of the watershed arrives.

<u>Increased Volume</u>

An important impact of new development is an increase in the total runoff volume of flow. Thus, even if the peak flow is effectively attenuated, the longer duration of higher flows due to the increased volume may combine with downstream tributaries to increase the downstream peak flows.

Figure 1.2.6.1b illustrates this concept. The figure shows the pre- and post-development hydrographs from a development site (Tributary 1). The post-development runoff hydrograph meets the flood protection criteria (i.e., the post-development peak flow is equal to the pre-development peak flow at the outlet from the site). However, the post-development combined flow at the first downstream tributary (Tributary 2) is higher than pre-development combined flow. This is because the increased volume and timing of runoff from the developed site increases the combined flow and flooding downstream. In this case, the detention volume would have to have been increased to account for the downstream timing of the combined hydrographs to mitigate the impact of the increased runoff volume.

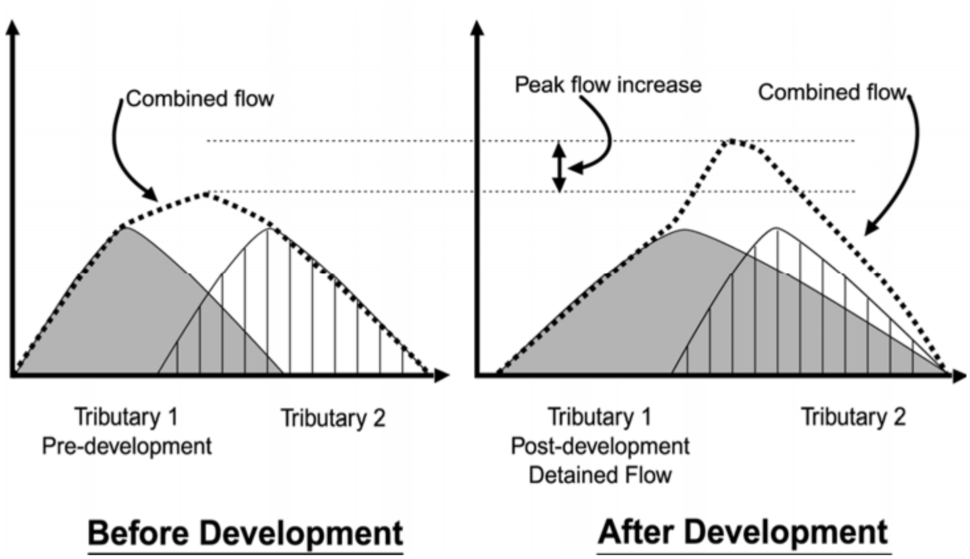


Figure 1.2.6.1b
Effect of Increased Post-Development Runoff Volume with Detention on a Downstream Hydrograph

1.2.6.2 Methods for Downstream Evaluation

The downstream assessment is a tool by which the impacts of development on storm water peak flows and velocities are evaluated downstream. The assessment extends from an outfall of a development to a point downstream, determined by one of two methods:

• *Zone of Influence* – Point downstream where the discharge from a proposed development no longer has a significant impact upon the receiving stream or storm drainage system

• *Adequate Outfall* – Location of acceptable outfall that does not create adverse flooding or erosion conditions downstream

These methods recognize the fact that a structural control providing detention has a "zone of influence" downstream where its effectiveness can be felt. Beyond this zone of influence the storm water effects of a structural control become relatively small and insignificant compared to the runoff from the total drainage area at that point. Based on studies and master planning results for a large number of sites, a general rule of thumb is that the zone of influence can be considered to be the point where the drainage area controlled by the detention or storage facility comprises 10% of the total drainage area. This is known as the *10% Rule*. As an example, if a structural control drains 10 acres, the zone of influence ends at the point where the total drainage area is 100 acres or greater.

Typical steps in a downstream assessment include:

1. Determine the outfall location of the site and the pre- and post-development site conditions.

2. Using a topographic map determine a preliminary lower limit of the zone of influence (approximately 10% point).

3. Using a hydrologic model determine the pre-development peak flows and velocities at each junction beginning at the development outfall and ending at the next junction beyond the 10% point.

Undeveloped off-site areas are modeled as “full build-out” for both the pre- and post-development analyses. The discharges and velocities are evaluated for three storms:

- “Streambank Protection” storm, either the 1- or 2- year, 24-hour event
- “Conveyance” storm of either the 5-, 10-, or 25-year, 24-hour event
- 100-year, 24-hour storm event

4. Change the land use on the site to post-development conditions and rerun the model.

5. Compare the pre- and post-development peak discharges and velocities at the downstream end of the model. If the post-developed flows are higher than the pre-developed flows for the same frequency event, or the post-developed velocities are higher than the allowable velocity of the downstream receiving system, extend the model downstream. Repeat steps 3 and 4 until the postdevelopment flows are less than the pre-developed flows, and the post-developed velocities are below the allowable velocity. Allowable velocities are given in Tables 1.2.6.2 a and b below.

6. If shown that no peak flow increases occur downstream, and post-developed velocities are allowable, then the control of the flood protection volume (Q_f) can be waived by the local authority. The developer saves the cost of sizing a detention basin for flood control. In this case the downstream assessment saved the construction of an unnecessary structural control facility that would have been detrimental to the watershed flooding problems. In some communities this situation may result in a fee being paid to the local government in lieu of detention. That fee would go toward alleviating downstream flooding or making channel or other conveyance improvements.

7. If peak discharges are increased due to development, or if downstream velocities are erosive, one of the following options are required.

- Document that existing downstream conveyance is adequate to convey post-developed storm water discharges (Option 1 for Streambank Protection and Flood Control)
- Work with the local government to reduce the flow elevation and/or velocity through channel or flow conveyance structure improvements downstream. (Option 2 for Streambank Protection and Flood Control)
- Design an on-site structural control facility such that the post-development flows do not increase the peak flows, and the velocities are not erosive, at the outlet and the determined junction locations.

Even if the results of the downstream assessment indicate that no downstream flood or erosion protection is required, the water quality controls still need to be addressed.

Table 1.2.6.2 a - Roughness Coefficients and Maximum Allowable Velocities for Natural Watercourses

Channel Description	**Manning's n**	**Maximum Permissable Channel Velocity (ft/sec)**
MINOR NATURAL STREAMS		
Fairly regular section		
1. Some grass and weeds; little or no brush	0.03	3 to 6
2. Dense growth of weeds, depth of flow materially greater than weed height	0.035	3 to 6
3. Some weeds, light brush on banks	0.03	3 to 6
4. Some weeds, heavy brush on banks	0.05	3 to 6
5. Some weeds, dense willows on banks	0.06	3 to 6

For trees within channels with branches submerged at high stage, increase above values by….	0.01	
Irregular section with pools, slight channel meander, increase above values by….	0.01	
Floodplain – Pasture		
1. Short grass	0.03	3 to 6
2. Tall grass	0.035	3 to 6
Floodplain – Cultivated Areas		
1. No crop	0.03	3 to 6
2. Mature row crops	0.035	3 to 6
3. Mature field crops	0.04	3 to 6
Floodplain – Uncleared		
1. Heavy weeds scattered brush	0.05	3 to 6
2. Wooded	0.12	3 to 6
MAJOR NATURAL STREAMS		
Roughness coefficient is usually less than for minor streams of similar description on account of less effective resistance offered by irregular banks or vegetation on banks. Values of "n" for larger streams of mostly regular sections, with no boulders or brush	Range from 0.028 to 0.060	3 to 6
UNLINED VEGETATED CHANNELS		
Clays (Bermuda Grass)	0.035	5 to 6
Sandy and Silty Soils (Bermuda Grass)	0.035	3 to 5
UNLINED NON-VEGETATED CHANNELS		
Sandy Soils	0.03	1.5 to 2.5
Silts	0.03	0.7 to 1.5
Sandy Silts	0.03	2.5 to 3.0
Clays	0.03	3.0 to 5.0
Coarse Gravels	0.03	5.0 to 6.0
Shale	0.03	6.0 to 10.0
Rock	0.025	15

Table 1.2.6.2 b Maximum Velocities for Vegetative Channel Linings

Vegetation Type	Slope Range % (1)	Maximum Velocity (ft/sec) (2)
Bermuda grass	0-5	6
Bahia		4
Tall fescue grass mixtures (3)	0-10	4
Kentucky bluegrass	0-5	6
Buffalo grass	5-10	5
	>10	4
Grass mixture	0-5 (1)	4
	5-10	3
Sericea lespedeza, Weeping lovegrass, Alfalfa	0-5 (4)	3
Annuals (5)	0-5	3
Sod		4
Lapped sod		5

1 Do not use on slopes steeper than 10% except for side-slope in combination channel.
2 Use velocities exceeding 5% only when good stands can be maintained.
Mixtures of tall fescue, bahia, and/or
3 bermuda
4 Do not use on slopes steeper than 10% except for side-slope in combination channel.
5 Use on mild slopes or as temporary protection until permanent covers are established.

1.2.6.3 Example Problem

Figure 1.2.6.3 illustrates the concept of the ten-percent rule for two sites in a watershed.

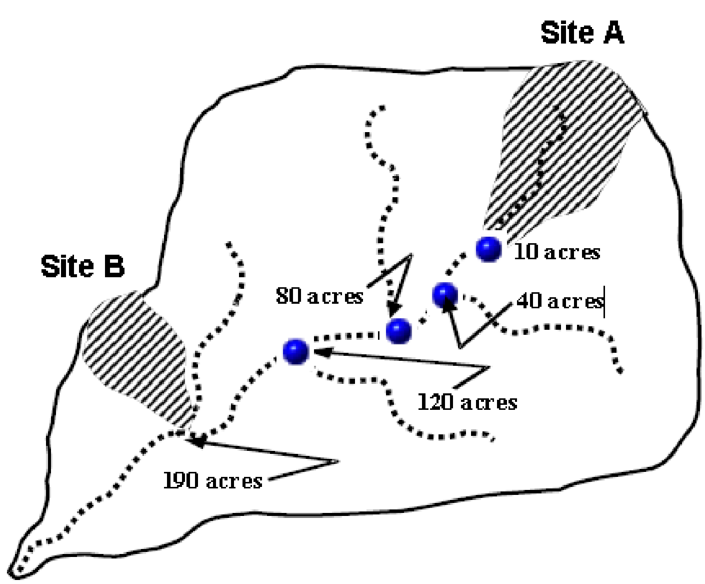
Discussion

Site A is a development of 10 acres, all draining to a wet Extended Detention (ED) storm water pond. The flood portions of the design are going to incorporate the ten-percent rule. Looking downstream at each tributary in turn, it is determined that the analysis should end at the tributary marked “80 acres.” The 100-acre (10%) point is in between the 80-acre and 120-acre tributary junction points.

The assumption is that if there is no peak flow increase or erosive velocities at the 80-acre point then the same will be true through the next stream reach downstream through the 10% point (100 acres) to the 120-acre point. The designer constructs a simple HEC-1 model of the 80-acre areas using single, “full build-out” condition sub-watersheds for each tributary. Key detention structures existing in other tributaries must be modeled. An approximate curve number is used since the *actual* peak flow is not key for initial analysis; only the increase or decrease is important. The accuracy in curve number determination is not as significant as an accurate estimate of the time of concentration. Since flooding is an issue downstream, the pond is designed (through several iterations) until the peak flow does not increase, and velocities are not erosive, at junction points downstream to the 80-acre point.

Site B is located downstream at the point where the total drainage area is 190 acres. The site itself is only 6 acres. The first tributary junction downstream from the 10% point is the junction of the site outlet with the stream. The total 190 acres is modeled as one basin with care taken to estimate the time of concentration for input into the TR-20 model of the watershed. The model shows a detention facility, in this case, will actually *increase* the peak flow in the stream.

Figure 1.2.6.3
Illustration of
Ten-Percent Rule



Section 1.3 Stormwater Site Design Practices

1.3.1 Overview

1.3.1.1 Introduction

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

- Managing stormwater (quantity and quality) as close to the point of origin as possible and minimizing collection and conveyance
- Preventing stormwater impacts rather than mitigating them
- Utilizing simple, nonstructural methods for stormwater management that are lower cost and lower maintenance than structural controls
- Creating a multifunctional landscape
- Using hydrology as a framework for site design
- Reducing the peak runoff rates and volumes, therefore, reducing the size and cost of drainage infrastructure and structural stormwater controls

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

Reduction of adverse stormwater runoff impacts through the use of stormwater site design should be the first consideration of the design engineer. Operationally, economically, and aesthetically, the use of stormwater site design practices offers significant benefits over treating and controlling runoff downstream. Therefore, all opportunities for using these methods should be explored and all options exhausted before considering structural stormwater controls.

The reduction in runoff and pollutants using stormwater site design can reduce the required runoff peak and volumes that need to be conveyed and controlled on a site and, therefore, the size and cost of necessary drainage infrastructure and structural stormwater controls. In some cases, the use of stormwater site design practices may eliminate the need for structural controls entirely. Hence, stormwater site design practices can be viewed as both a water quantity and water quality management tool.
Several of the site design practices described in this section provide a calculable reduction in the volume requirements for Water Quality Protection. Section 1.2.3.2 discusses these reduction opportunities and provides examples of their application. Furthermore, a point value has been assigned to each site design practice. Various types of credits are available for a development depending on the amount of points accumulated. Section 1.3.4 describes this point system in more detail.

The use of stormwater site design can also have a number of other ancillary benefits including:

Reduced construction costs
Increased property values

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

1.3.1.2 List of Stormwater Site Design Practices and Techniques

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

- **Conservation of Natural Features and Resources**
    - Preserve Undisturbed Natural Areas
    - Preserve Riparian Buffers
    - Avoid Floodplains
    - Avoid Steep Slopes
    - Minimize Siting on Porous or Erodible Soils
- **Lower Impact Site Design Techniques**
    - Fit Design to the Terrain
    - Locate Development in Less Sensitive Areas
    - Reduce Limits of Clearing and Grading
    - Utilize Open Space Development
    - Consider Creative Designs
- **Reduction of Impervious Cover**
    - Reduce Building Footprints
    - Use Fewer or Alternative Cul-de-Sacs
    - Create Parking Lot Stormwater "Islands"
- **Utilization of Natural Features for Stormwater Management**
    - Use Buffers and Undisturbed Areas
    - Use Natural Drainageways Instead of Storm Sewers
    - Use Vegetated Swale Instead of Curb and Gutter
    - Drain Rooftop Runoff to Pervious Areas

More detail on each site design practice is provided in the Stormwater Site Design Practice Summary Sheets in subsection 1.3.2. The Summary Sheets are after the work of the Center for Watershed Protection found in its 1998 publication **Better Site Design: A Handbook for changing Development Rules in Your Community**. These summaries provide the key benefits of each practice, examples, and details on how to apply them in site design.

1.3.1.3 Using Stormwater Site Design Practices

Site design should be done in unison with the design and layout of stormwater infrastructure in attaining stormwater management goals. Figure 1.3.1-1 illustrates the stormwater site design process that utilizes the four stormwater site design categories.

Figure 1.3.1-1 Stormwater Site Design Process

The first step in stormwater site design involves identifying significant natural features and resources on a site such as undisturbed forest areas, stream buffers and steep slopes that should be preserved to retain some of the original hydrologic function of the site.

Next, the site layout is designed such that these conservation areas are preserved and the impact of the development is minimized. A number of techniques can then be used to reduce the overall imperviousness of the development site.

Finally, natural features and conservation areas can be utilized to serve stormwater quantity and quality management purposes.

1.3.2 Stormwater Site Design Practices

1.3.2.1 Conservation of Natural Features and Resources

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

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

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

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

Delineation of natural features is typically done through a comprehensive site analysis and inventory before any site layout design is performed (see Subsection 1.1.3.4). From this site analysis, a concept plan for a site can be prepared that provides for the conservation and protection of natural features. Figure 1.3.2-1 shows an example of the delineation of natural features on a base map of a development

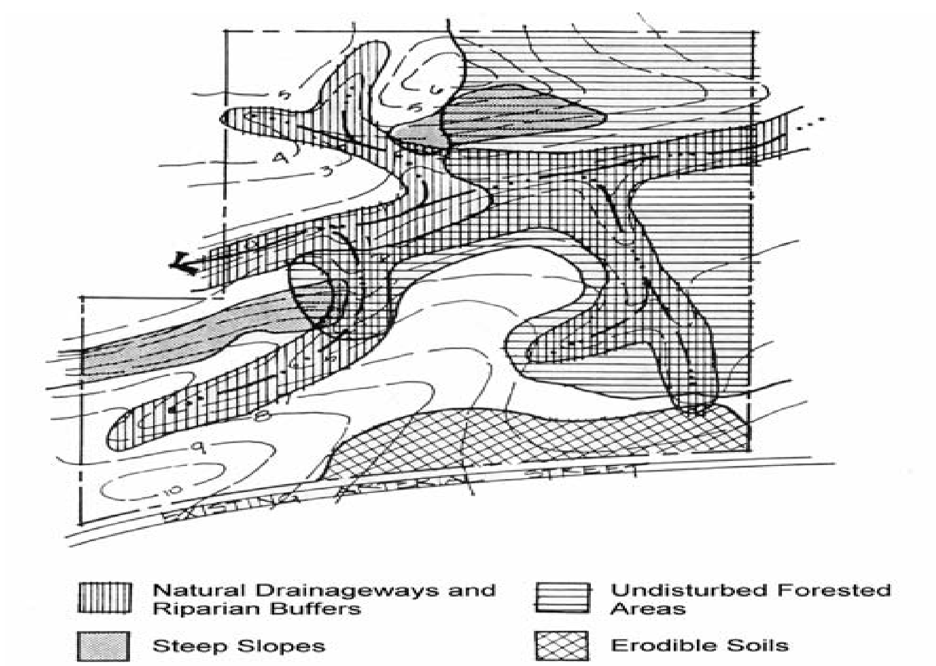


Figure 1.3.2-1 Example of Natural Feature Delineation
(Source: MPCA, 1989)

Stormwater Site Design Practice #1:

Preserve Undisturbed Natural Areas

Conservation of Natural Features and Resources

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

KEY BENEFITS	USING THIS PRACTICE
• Helps to preserve a portion of the site's natural predevelopment hydrology • Can be used as nonstructural storm water filtering and infiltration zones • Helps to preserve the site's natural character and aesthetic features • May increase the value of the developed property • A storm water site design credit can be taken if allowed by the local review authority	☑ Delineate natural areas before performing site layout and design ☑ Ensure that conservation areas are protected in an *undisturbed state* throughout construction and occupancy

Discussion

Preserving natural conservation areas such as undisturbed forested and vegetated areas, natural drainageways, stream corridors and wetlands on a development site helps to preserve the original hydrology of the site and aids in reducing the generation of stormwater runoff and pollutants. Undisturbed vegetated areas also stabilize soils, provide for filtering and infiltration, decreases evaporation, and increases transpiration.

Natural conservation areas are typically identified through a site analysis using maps and aerial/satellite photography, or by conducting a site visit. These areas should be delineated before any site design, clearing or construction begins. When done before the concept plan phase, the planned conservation areas can be used to guide the layout of the site. Figure 1.3.2-2 shows a site map with undisturbed natural areas delineated.

Conservation areas should be incorporated into site plans and clearly marked on all construction and grading plans to ensure equipment is kept out of these areas and native vegetation is kept in an undisturbed state. The boundaries of each conservation area should be mapped by carefully determining the limit that should not be crossed by construction activity.

Once established, natural conservation areas must be protected during construction and Natural conservation areas must be managed after occupancy by a responsible party able to maintain the areas in a natural state in perpetuity. Typically, conservation areas are protected by legally enforceable deed restrictions, conservation easements, and maintenance agreements. Permanent signage and fences should be required.

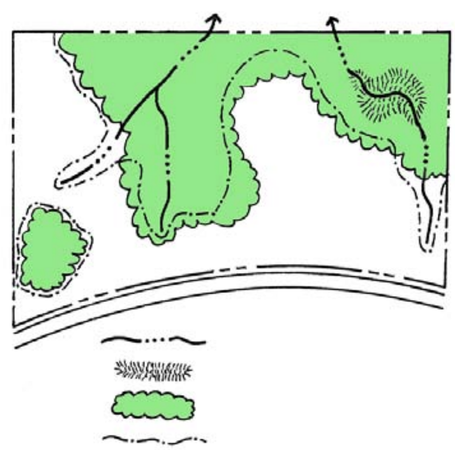


Figure 1.3.2-2 Delineation of Natural Conservation Areas

Preserve Riparian Buffers

Description: Naturally vegetated buffers should be delineated and preserved along perennial streams, rivers, lakes, and wetlands.

KEY BENEFITS	USING THIS PRACTICE
• Can be used as nonstructural storm water filtering and infiltration zones • Keeps structures out of the floodplain and provides a right-of-way for large flood events • Helps to preserve riparian ecosystems and habitats • A storm water site design reduction credit can be taken if allowed by the local review authority	☑ Delineate and preserve naturally vegetated riparian buffers ☑ Ensure buffers and native vegetation are protected throughout construction and occupancy

Discussion

A riparian buffer is a special type of natural conservation area along a stream, wetland or shoreline where development is restricted or prohibited. The primary function of buffers is to protect and physically separate a stream, lake or wetland from future disturbance or encroachment. If properly designed, a buffer can provide stormwater management functions, can act as a right-of-way during floods, and can sustain the integrity of stream ecosystems and habitats. An example of a riparian stream buffer is shown in Figure 1.3.2-3.

Forested riparian buffers should be maintained and reforestation should be encouraged where no wooded buffer exists. Proper restoration should include all layers of the forest plant community, including understory, shrubs and groundcover, not just trees. A riparian buffer can be of fixed or variable width, but should be continuous and not interrupted by impervious areas that would allow stormwater to concentrate and flow into the stream without first flowing through the buffer.

Figure 1.3.2-3 Riparian Stream Buffer

Ideally, riparian buffers should be sized to include the 100-year floodplain as well as steep banks and wetlands. The buffer depth needed to perform properly will depend on the size of the stream and the surrounding conditions, but a minimum 25-foot undisturbed vegetative buffer is needed for even the smallest perennial streams and a 50-foot or larger undisturbed buffer is ideal. Even with a 25-foot undisturbed buffer, additional zones can be added to extend the total buffer to at least 75 feet from the edge of the stream. The three distinct zones within the 75-foot depth are shown in Figure 1.3.2-4. The function, vegetative target and allowable uses vary by zone as described in Table 1.3.2-1.

These recommendations are minimum standards to apply to most streams. Some streams and watershed may require additional measures to achieve protection. In some areas, specific state laws or local ordinances already require stricter buffers than are described here. The buffer widths discussed are not intended to modify or supercede deeper or more restrictive buffer requirements already in place.

As stated above, the streamside or inner zone should consist of a minimum of 25 feet of undisturbed mature forest. In addition to runoff protection, this zone provides bank stabilization as well as shading and protection for the stream. This zone should also include wetlands and any critical habitats, and its width should be adjusted accordingly. The middle zone provides a transition between upland development and the inner zone and should consist of managed woodland that allows for infiltration and filtration of runoff. An outer zone allows more clearing and acts as a further setback for impervious surfaces. It also functions to prevent encroachment and filter runoff. In the outer zone, flow into the buffer should be transformed from concentrated flow into sheet flow to maximize ground contact with the runoff.

Development within the riparian buffer should be limited only to those structures and facilities that are absolutely necessary. Such limited development should be specifically identified in any codes or ordinances enabling the buffers. When construction activities do occur within the riparian corridor, specific mitigation measures should be required, such as larger buffers or riparian buffer improvements.

Generally, the riparian buffer should remain in its natural state. However, some maintenance is periodically necessary, such as planting to minimize concentrated flow, the removal of exotic plant species when these species are detrimental to the vegetated buffer and the removal of diseased or damaged trees.

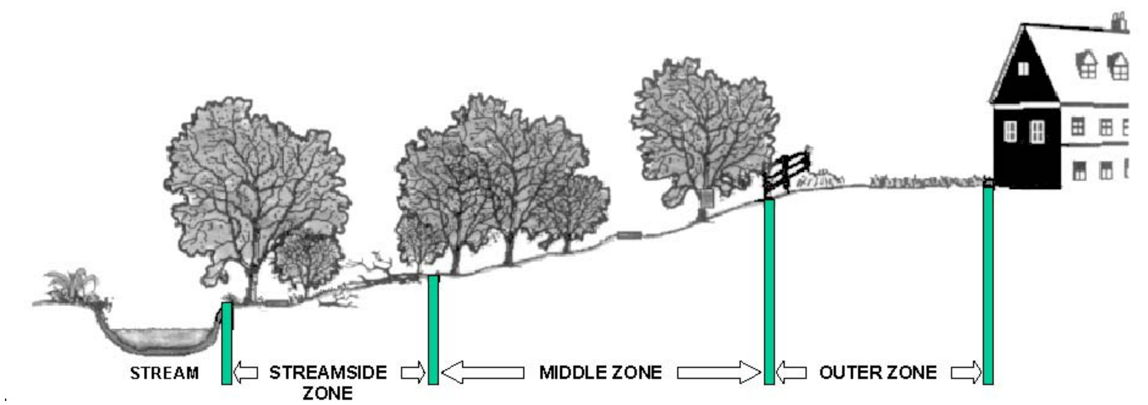


Figure 1.3.2-4 Three-Zone Stream Buffer System

Table 1.3.2-1	**Riparian Buffer Management Zones**		
	Streamside Zone	Middle Zone	Outer Zone
Width	Minimum 25 feet plus wetlands and critical habitat	Variable depending on stream order, slope, and 100-year floodplain (min. 25 ft)	25-foot minimum setback from structures
Vegetative Target	Undisturbed mature forest. Reforest if necessary.	Managed forest, some clearing allowed.	Forest encouraged, but turf grass at a minimum
Allowable Uses	**Very Restricted** e.g., flood control, utility easements, footpaths	**Restricted** e.g., some recreational uses, some stormwater controls, bike paths	**Unrestricted** e.g., residential uses including lawn, garden, most stormwater controls

Stormwater Site Design Practice #3:

Avoid Floodplains

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

KEY BENEFITS	USING THIS PRACTICE
• Provides a natural right-of-way and temporary storage for large flood events • Keeps people and structures out of harm's way • Helps to preserve riparian ecosystems and habitats • Can be combined with riparian buffer protection to create linear greenways	☑ Obtain maps of the 100-year floodplain from the local review authority ☑ Ensure all development activities do not encroach on the designated floodplain areas

Discussion

Floodplains are the low-lying lands that border streams and rivers. When a stream reaches its capacity and overflows its channel after storm events, the floodplain provides for storage and conveyance of these excess flows. In their natural state they reduce flood velocities and peak flow rates by the passage of flows through dense vegetation. Floodplains also play an important role in reducing sedimentation by filtering runoff, and provide habitat for both aquatic and terrestrial life. Development in floodplain areas can reduce the ability of the floodplain to convey stormwater, potentially causing safety problems or significant damage to the site in question, as well as to both upstream and downstream properties. Most communities regulate the use of floodplain areas to minimize the risk to human life as well as to avoid flood damage to structures and property.

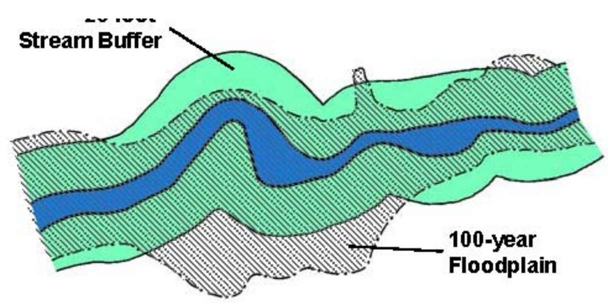


Figure 1.3.2-5 Floodplain Boundaries in Relation to a Riparian Buffer

As such, floodplain areas should be avoided on a development site. Ideally, the entire 100-year full-buildout floodplain should be avoided for clearing or building activities, and should be preserved in a natural undisturbed state where possible. Floodplain protection is complementary to riparian buffer preservation. Both of these stormwater site design practices preserve stream corridors in a natural state and allow for the protection of vegetation and habitat. Depending on the site topography, 100-year floodplain boundaries may lie inside or outside of a preserved riparian buffer corridor, as shown in Figure 1.3.2-5.

Maps of the 100-year floodplain can typically be obtained through the local review authority. Developers and builders should also ensure their site designs comply with any other relevant local floodplain and FEMA requirements.

Avoid Steep Slopes

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

KEY BENEFITS	USING THIS PRACTICE
• Preserving steep slopes helps to prevent soil erosion and degradation of storm water runoff quality • Steep slopes can be kept in an undisturbed natural condition to help stabilize hillsides and soils • Building on flatter areas will reduce the need for cut-and-fill and grading	☑ Avoid development on steep slope areas, especially those with a grade of 15% or greater. ☑ Minimize grading and flattening of hills and ridges

Discussion

Developing on steep slope areas has the potential to cause excessive soil erosion and increased stormwater runoff during and after construction. Past studies by the SCS (now NRCS) and others have shown that soil erosion is significantly increased on slopes of 15% or greater. In addition, the nature of steep slopes means that greater areas of soil and land area are disturbed to locate facilities on them compared to flatter slopes as demonstrated in Figure 1.3.2-6.

Therefore, development on slopes with a grade of 15% or greater should be avoided if possible to limit soil loss, erosion, excessive stormwater runoff, and the degradation of surface water. Excessive grading should be avoided on all slopes, as should the flattening of hills and ridges. Steep slopes should be kept in an undisturbed natural condition to help stabilize hillsides and soils. If slopes are already bare and eroding, controls to stabilize and revegetate the slopes must be considered.

On slopes greater than 25%, no development, regrading, or stripping of vegetation should be considered unless the disturbance is for roadway crossings or utility construction and it can be demonstrated that the roadway or utility improvements are absolutely necessary in the sloped area.

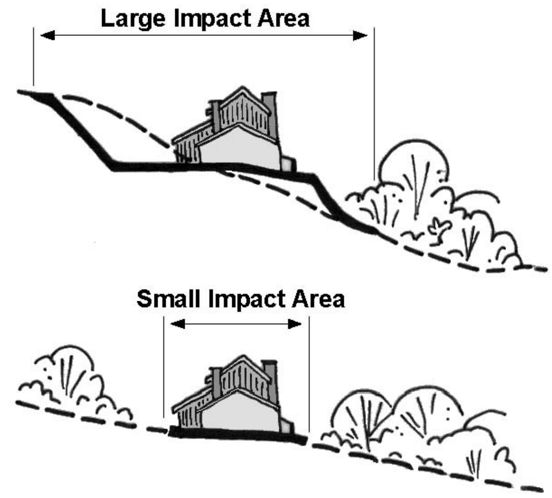


Figure 1.3.2-6 Flattening Steep Slopes for Building Sites Uses More Land Area than Building on Flatter Slopes
(Source: MPCA, 1989)

Minimize Siting on Permeable or Erodible Soils

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

KEY BENEFITS	USING THIS PRACTICE
• Areas with highly permeable soils can be used as nonstructural storm water infiltration zones. A storm water site design credit can be taken if allowed by the local review authority • Avoiding highly erodible or unstable soils can prevent erosion and sedimentation problems and water quality degradation	☑ Use soil surveys to determine site soil types ☑ Leave areas of porous or highly erodible soils as undisturbed conservation areas

Discussion

Infiltration of stormwater into the soil reduces both the volume and peak discharge of runoff from a given rainfall event, and also provides for water quality treatment and groundwater recharge. Soils with maximum permeabilities (hydrologic soil group A and B soils such as sands and sandy loams) allow for the most infiltration of runoff into the subsoil. Thus, areas of a site with these soils should be conserved as much as possible and these areas should ideally be incorporated into undisturbed natural or open space areas. Conversely, buildings and other impervious surfaces should be located on those portions of the site with the *least* permeable soils to the extent that soil stability, shrink-swell potential, and other soil characteristics allow.

Similarly, areas on a site with highly erodible or unstable soils should be avoided for land disturbing activities and buildings to prevent erosion and sedimentation problems as well as potential future structural problems. These areas should be left in an undisturbed and vegetated condition.

Soils on a development site should be mapped in order to preserve areas with permeable soils, and to identify those areas with unstable or erodible soils as shown in Figure 1.3.2-7. Soil surveys can provide a considerable amount of information relating to all relevant aspects of soils. Refer to the Soil Survey of Rutherford County published by the Soil Conservation Service for permeability, shrink- swell potential and hydrologic soils group information for all Rutherford County soil series. General soil types should be delineated on concept site plans to guide site layout and the placement of buildings and impervious surfaces.

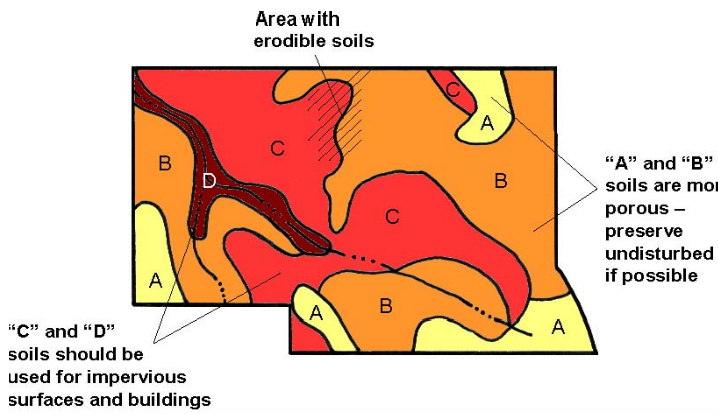


Figure 1.3.2-7 Soil Mapping Information Can Be Used to Guide Development

1.3.2.2 Lower Impact Site Design Techniques

After a site analysis has been performed and conservation areas have been delineated, there are numerous opportunities in the site design and layout phase to reduce both water quantity and quality impacts of stormwater runoff. These primarily deal with the location and configuration of impervious surfaces or structures on the site and include the following practices and techniques covered over the next several pages:

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

The goal of lower impact site design techniques is to lay out the elements of the development project in such a way that the site design (i.e. placement of buildings, parking, streets and driveways, lawns, undisturbed vegetation, buffers, etc.) is optimized for effective stormwater management. That is, the site design takes advantage of the site's natural features, including those placed in conservation areas, as well as any site constraints and opportunities (topography, soils, natural vegetation, floodplains, shallow bedrock, high water table, etc.) to prevent both on-site and downstream stormwater impacts.

Figure 1.3.2-8 shows a development that has utilized several lower impact site design techniques in its overall layout and design.

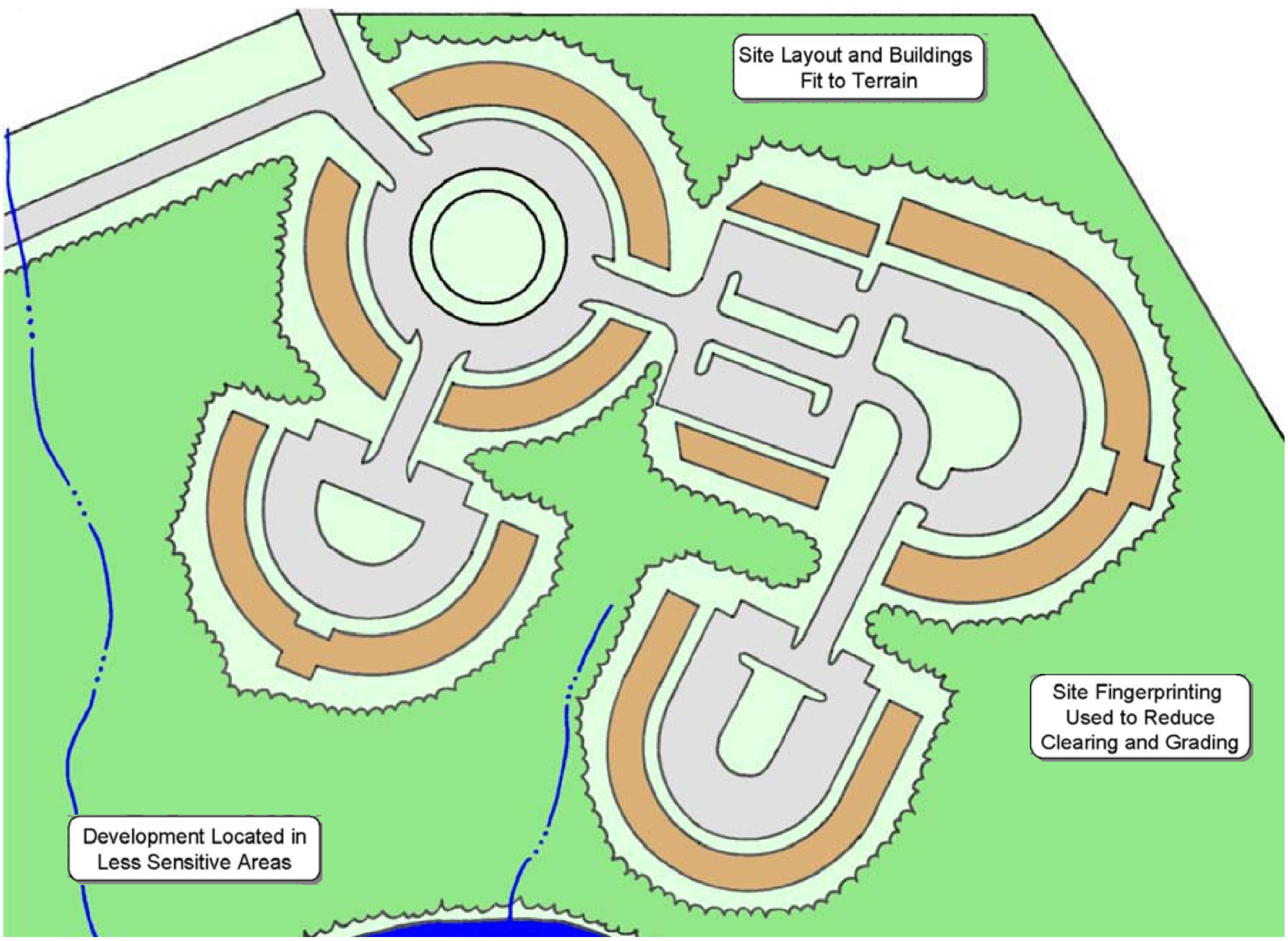


Figure 1.3.2-8 Development Design Utilizing Several Lower Impact Site Design Techniques

Fit Design to the Terrain

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

KEY BENEFITS	USING THIS PRACTICE
• Helps to preserve the natural hydrology and drainageways of a site • Reduces the need for grading and land disturbance • Provides a framework for site design and layout	☑ Develop roadway patterns to fit the site terrain. ☑ Locate buildings and impervious surfaces away from steep slopes, drainageways and floodplains

Discussion

All site layouts should be designed to conform with or "fit" the natural landforms and topography of a site. This helps to preserve the natural hydrology and drainageways on the site, as well as reduces the need for grading and disturbance of vegetation and soils. Figure 1.3.2-9 illustrates the placement of roads and homes in a residential development.

Roadway patterns on a site should be chosen to provide access schemes which match the terrain. In rolling or hilly terrain, streets should be designed to follow natural contours to reduce clearing and grading. Street hierarchies with local streets branching from collectors in short loops and cul-de-sacs along ridgelines help to prevent the crossing of streams and drainageways as shown in Figure 1.3.2-10. In flatter areas, a traditional grid pattern of streets or "fluid" grids which bend and may be interrupted by natural drainageways may be more appropriate (see Figure 1.3.2-11). A grid pattern may also allow for narrower streets and less imperviousness as having more than one route for emergency vehicles makes it easier to relax minimum street width requirements. In either case, buildings and impervious surfaces should be kept off of steep slopes, away from natural drainageways, and out of floodplains and other lower lying areas. In addition, the major axis of buildings should be oriented parallel to existing contours.

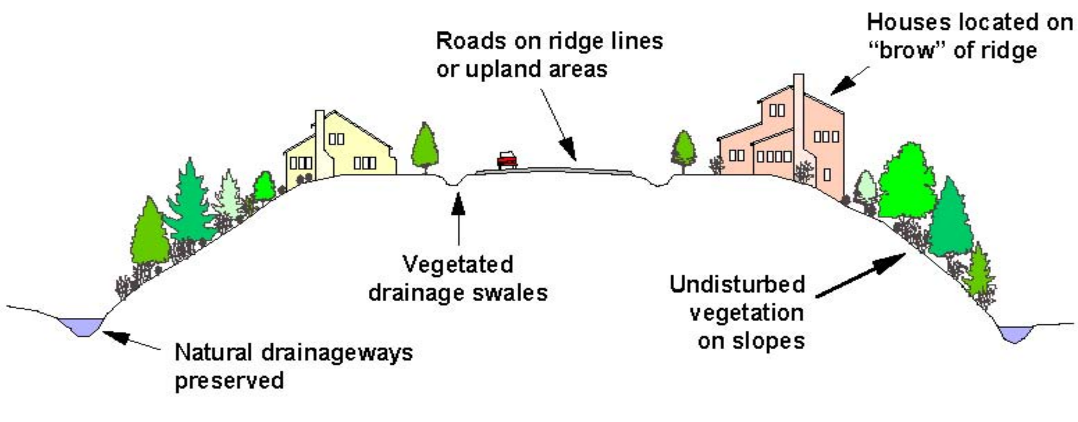


Figure 1.3.2-9 Preserving the Natural Topography of the Site
(Adapted from Sykes, 1989)

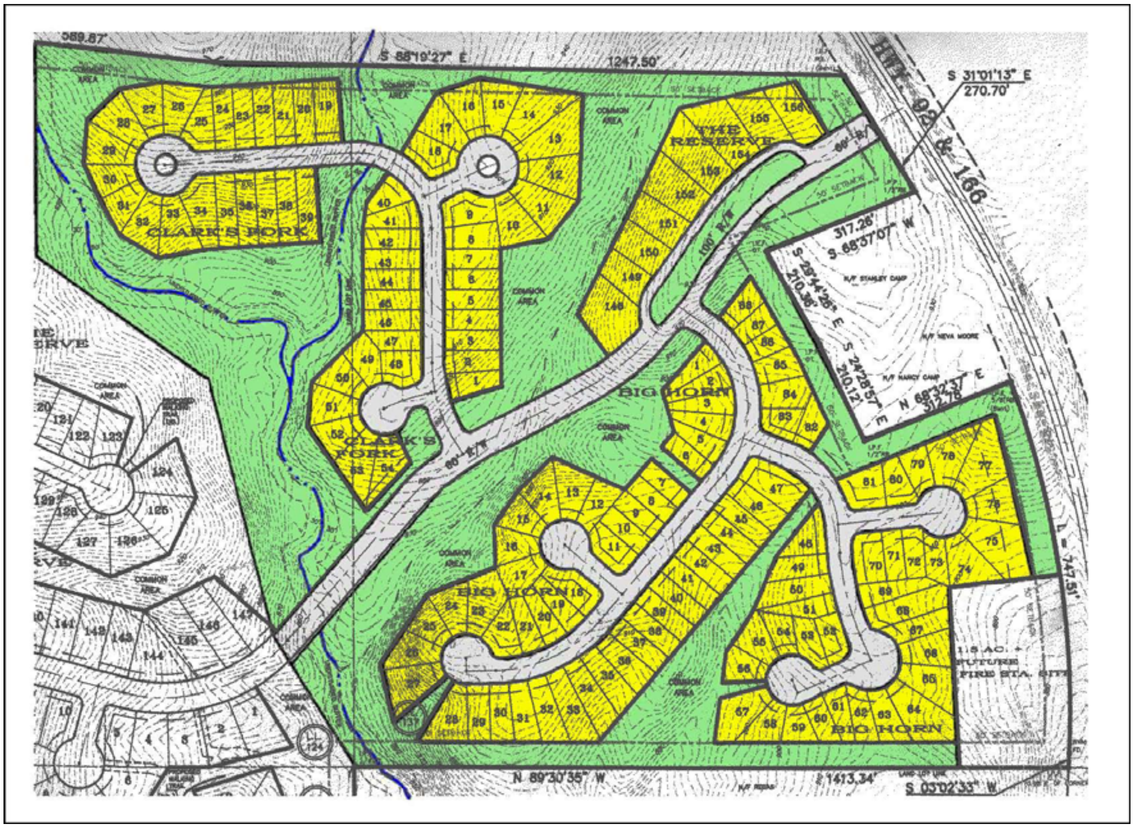


Figure 1.3.2-10 Subdivision Design for Hilly or Steep Terrain Utilizes Branching Streets from Collectors that Preserves Natural Drainageways and Stream Corridors

Figure 1.3.2-11 A Subdivision Design for Flat Terrain Uses a Fluid Grid Layout that is Interrupted by the Stream Corridor

Stormwater Site Design Practice #7:

Locate Development in Less Sensitive Areas

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

KEY BENEFITS	USING THIS PRACTICE
• Helps to preserve the natural hydrology and drainageways of a site • Makes most efficient use of natural site features for preventing and mitigating storm water impacts • Provides a framework for site design and layout	☑ Lay out the site design to minimize the hydrologic impact of structures and impervious surfaces

Discussion

In much the same way that a development should be designed to conform to terrain of the site, a site layout should also be designed so the areas of development are placed in the locations of the site that minimize the hydrologic impact of the project. This is accomplished by steering development to areas of the site that are less sensitive to land disturbance or have a lower value in terms of hydrologic function using the following methods:

Locate buildings and impervious surfaces away from stream corridors, wetlands and natural drainageways. Use buffers to preserve and protect riparian areas and corridors.

Areas of the site with permeable soils should left in an undisturbed condition and/or used as stormwater runoff infiltration zones. Buildings and impervious surfaces should be located in areas with less permeable soils.

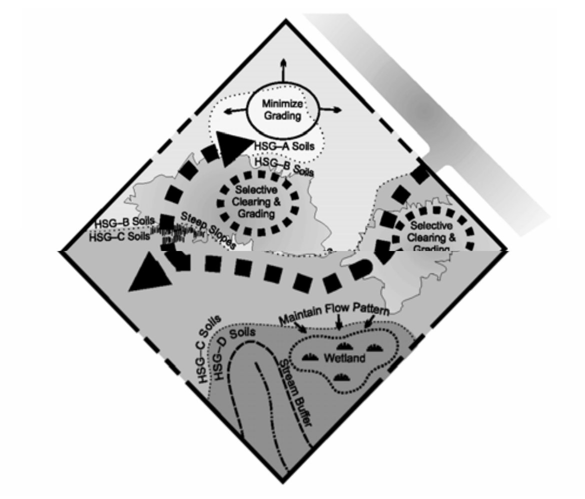


Figure 1.3.2-12 Guiding Development. to Less Sensitive Areas of a Site
(Source: Prince George's County, MD, 1999)

- ➢ Avoid land disturbing activities or construction on areas with steep slopes or unstable soils.
- ➢ Minimize the clearing of areas with dense tree canopy or thick vegetation, and ideally preserve them as natural conservation areas.
- ➢ Ensure natural drainageways and flow paths are preserved, where possible. Avoid the filling or grading of natural depressions and ponding areas.

Figure 1.3.2-12 shows a development site where the natural features have been mapped in order to delineate the hydrologically sensitive areas. Through careful site planning, sensitive areas can be set aside as natural open space areas (see Stormwater Site Design Practice #9). In many cases, such areas can be used as buffer spaces between land uses on the site or between adjacent sites

Reduce Limits of Clearing and Grading

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

KEY BENEFITS	USING THIS PRACTICE
• Preserves more undisturbed natural areas on a development site • Techniques can be used to help protect natural conservation areas and other site features	☑ Establish limits of disturbance for all development activities ☑ Use site footprinting to minimize clearing and land disturbance

Discussion

Minimal disturbance methods should be used to limit the amount of clearing and grading that takes place on a development site, preserving more of the undisturbed vegetation and natural hydrology of a site. These methods include:

- Establishing a limit of disturbance (LOD) based on maximum disturbance zone radii/lengths. These maximum distances should reflect reasonable construction techniques and equipment needs together with the physical situation of the development site such as slopes or soils. LOD distances may vary by type of development, size of lot or site, and by the specific development feature involved.
- Using site "footprinting" which maps all of the limits of disturbance to identify the smallest possible land area on a site which requires clearing or land disturbance. Examples of site footprinting are illustrated in Figures 1.3.2-13 and 1.3.2-14.
- Fitting the site design to the terrain.
- Using special procedures and equipment which reduce land disturbance.

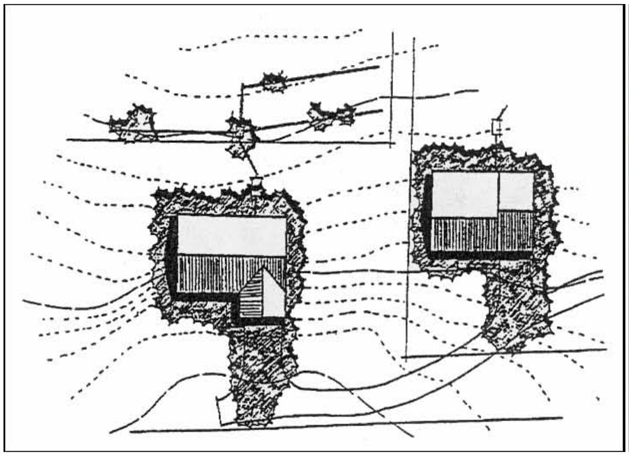


Figure 1.3.2-13 Establishing Limits of Clearing
(Source: DDNREC, 1997)

Figure 1.3.2-14 Example of Site Footprinting

Utilize Open Space Development

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

KEY BENEFITS	USING THIS PRACTICE
• Preserves conservation areas on a development site • Can be used to preserve natural hydrology and drainageways • Can be used to help protect natural conservation areas and other site features • Reduces the need for grading and land disturbance • Reduces infrastructure needs and overall development costs	☑ Use a site design which concentrates development and preserves open space and natural areas of the site

Discussion

Open space development, also known as *conservation development* or *clustering*, is a site design technique that concentrates structures and impervious surfaces in a compact area in one portion of the development site in exchange for providing open space and natural areas elsewhere on the site. Typically, smaller lots and/or nontraditional lot designs are used to cluster development and create more conservation areas on the site.

Open space developments have many benefits compared with conventional commercial developments or residential subdivisions: they can reduce impervious cover, stormwater pollution, construction costs, and the need for grading and landscaping, while providing for the conservation of natural areas. Figures 1.3.2-15 and 1.3.2-16 show examples of open space developments.

Along with reduced imperviousness, open space designs provide a host of other environmental benefits lacking in most conventional designs. These developments reduce potential pressure to encroach on conservation and buffer areas because enough open space is usually reserved to accommodate these protection areas. As less land is cleared during the construction process, alteration of the natural hydrology and the potential for soil erosion are also greatly diminished. Perhaps most importantly, open space design reserves 25 to 50 percent of the development site in conservation areas, which would not otherwise be protected.

Open space developments can also be significantly less expensive to build than conventional projects. Most of the cost savings are due to reduced infrastructure cost for roads and stormwater management controls and conveyances. While open space developments are frequently less expensive to build, developers also find these properties often command higher prices than those in more conventional developments. Several studies estimate that residential properties in open space developments garner premiums higher than conventional subdivisions resulting in higher selling or leasing rates.

Once established, common open space and natural conservation areas must be managed by a responsible party, typically a municipality, to maintain the areas in a natural state in perpetuity. Typically, the conservation areas are protected by legally enforceable deed restrictions, conservation easements, and maintenance agreements.

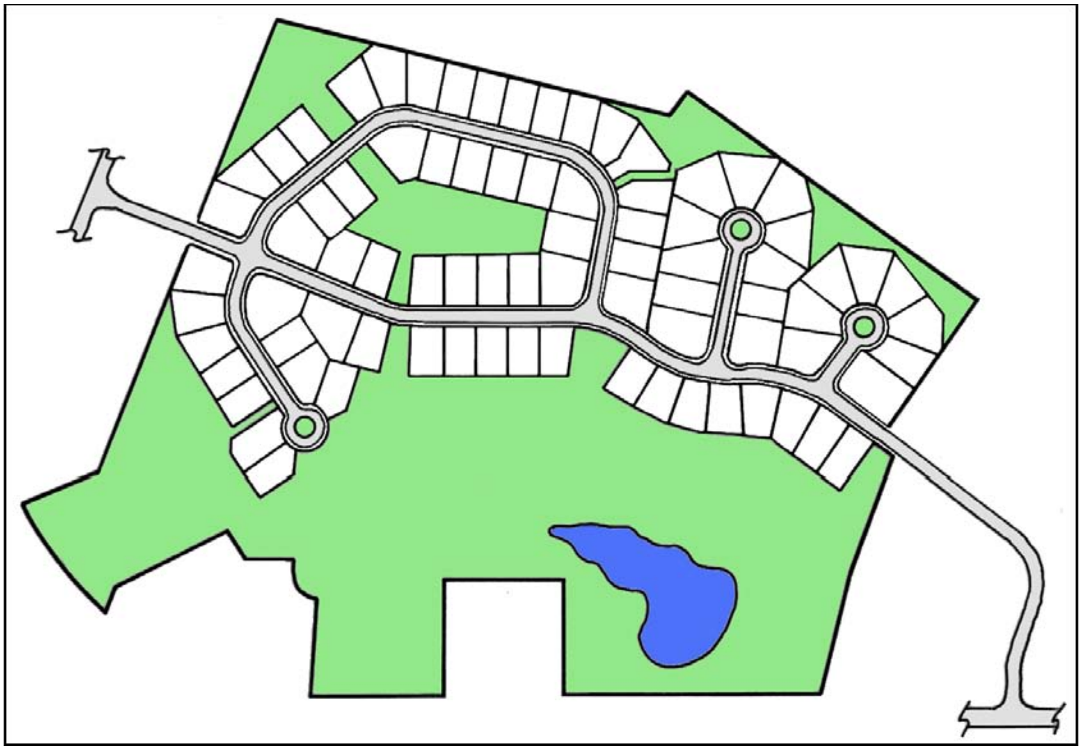


Figure 1.3.2-15 Open Space Subdivision Site Design Example

Figure 1.3.2-16 Aerial View of an Open Space Subdivision

Consider Creative Development Design

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

KEY BENEFITS	USING THIS PRACTICE
• Allows flexibility to developers to implement creative site designs which include *integrated* site design practices • May be useful for implementing an open space development	☑ Check with your local review authority to determine if the community supports PUDs ☑ Determine the type and nature of deviations allowed and other criteria for receiving PUD approval

Discussion

A Planned Unit Development (PUD) is a type of planning approval available in some communities which provides greater design flexibility by allowing deviations from the typical development standards required by the local zoning code with additional variances or zoning hearings. The intent is to encourage better designed projects through the relaxation of some development requirements, in exchange for providing greater benefits to the community. PUDs can be used to implement many of the other stormwater site design practices covered in this Manual and to create site designs that maximize natural nonstructural approaches to stormwater management.

Examples of the types of zoning deviations which are often allowed through a PUD process include:

- Allowing uses not listed as permitted, conditional or accessory by the zoning district in which the property is located
- Modifying lot size and width requirements
- Reducing building setbacks and frontages from property lines
- Altering parking requirements
- Increasing building height limits

Many of these changes are useful in reducing the amount of impervious cover on a development site (see Stormwater Site Design Practices #11 through #13).

A developer or site designer should consult the local review authority to determine whether the community supports PUD approvals. If so, the type and nature of deviations allowed from individual development requirements should be obtained from the review authority in addition to any other criteria that must be met to obtain a PUD approval.

1.3.2.3 Reduction of Impervious Cover

The level of impervious cover, i.e. rooftops, parking lots, roadways, sidewalks and other surfaces that do not allow rainfall to infiltrate into the soil, is an essential factor to consider in site design for stormwater management. Increased impervious cover means increased stormwater generation and increased pollutant loadings.

Thus by reducing the area of total impervious surface on a site, a site designer can directly reduce the volume of stormwater runoff and associated pollutants that are generated. It can also reduce the size and cost of necessary infrastructure for stormwater drainage, conveyance, and control and treatment. Some of the ways impervious cover can be reduced in a development include:

- Reduce Building Footprints
- Use Fewer or Alternative Cul-de-Sacs
- Create Parking Lot Stormwater Islands

Figure 1.3.2-17 shows an example of a residential subdivision that employed several of these principles to reduce the overall imperviousness of the development. The next several pages cover these methods in more detail.

Figure 1.3.2-17 Example of Reducing Impervious Cover (clockwise from upper left):
(a) Cul-de-sac with Landscaped Island; (b) Narrower Residential Street; (c) “Green” Parking Lot with Landscaped Islands; and (d) Landscape Median in Roadway.

Reduce Building Footprints

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

KEY BENEFITS	USING THIS PRACTICE
Reduces the amount of impervious cover and associated runoff and pollutants generated	Use alternate or taller building designs to reduce the impervious footprint of buildings

Discussion

In order to reduce the imperviousness associated with the footprint and rooftops of buildings and other structures, alternative and/or vertical (taller) building designs should be considered. Consolidate functions and buildings, as required, or segment facilities to reduce the footprint of individual structures. Figure 1.3.2-19 shows the reduction in impervious footprint by using a taller building design.

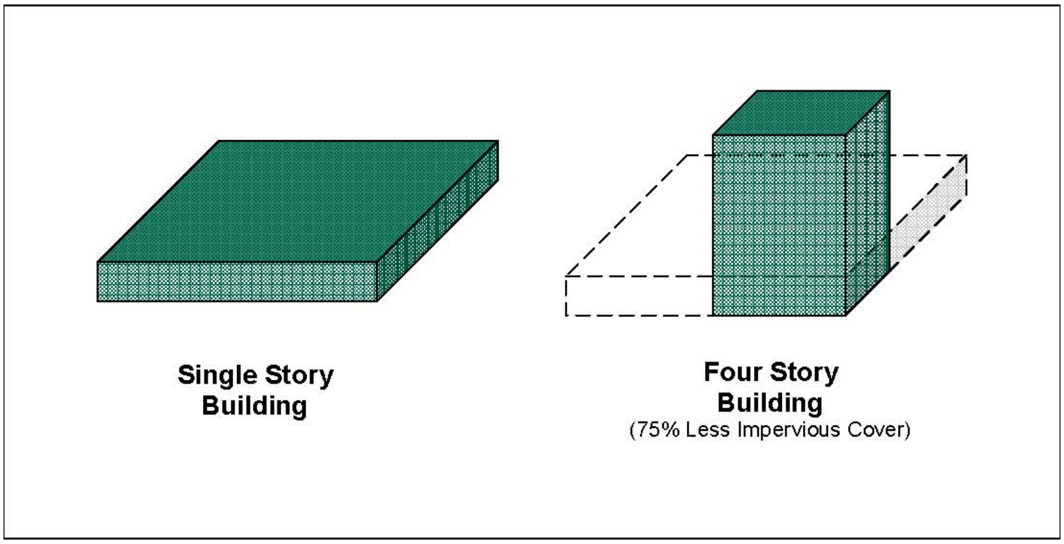


Figure 1.3.2-19 Building Up Rather Than Out Can Reduce the Amount of Impervious Cover

Stormwater Site Design Practice #12: **Reduction of Impervious Cover**

Use Fewer or Alternative Cul-de-Sacs

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

KEY BENEFITS	USING THIS PRACTICE
• Reduces the amount of impervious cover and associated runoff and pollutants generated	✓ Consider alternative cul-de-sac designs

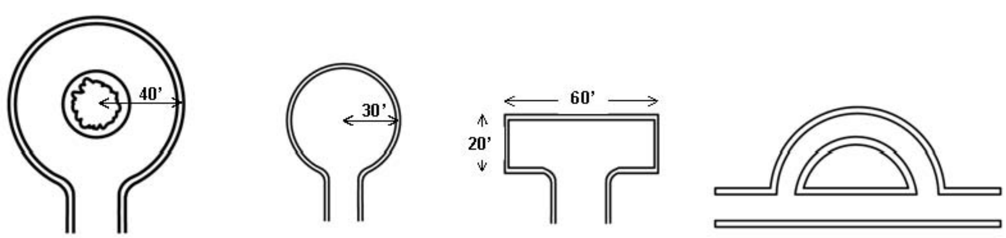
Discussion

Alternative turnarounds are designs for end-of-street vehicle turnarounds that replace cul-de-sacs and reduce the amount of impervious cover created in developments. Cul-de-sacs are local access streets with a closed circular end that allows for vehicle turnarounds. Many of these cul-de-sacs can have a radius of more than 40 feet. From a stormwater perspective, cul-de-sacs create a huge bulb of impervious cover, increasing the amount of runoff. For this reason, reducing the size of cul-de-sacs through the use of alternative turnarounds or eliminating them altogether can reduce the amount of impervious cover created at a site.

Numerous alternatives create less impervious cover than the traditional 40-foot cul-de-sac. These alternatives include reducing cul-de-sacs to a 30-foot radius and creating hammerheads, loop roads, and pervious islands in the cul-de-sac center (see Figure 1.3.2-25).

Sufficient turnaround area is a significant factor to consider in the design of cul-de-sacs. In particular, the types of vehicles entering into the cul-de-sac should be considered. Fire trucks, service vehicles and school buses are often cited as needing large turning radii. However, some fire trucks are designed for smaller turning radii. In addition, many newer large service vehicles are designed with a tri-axle (requiring a smaller turning radius) and many school buses usually do not enter individual cul-de-sacs.

Implementing alternative turnarounds will require addressing local regulations and marketing issues. Communities may have specific design criteria for cul-de-sacs and other alternative turnarounds that need to be modified.



40 ft cul-de sac with 30 ft radius 60 by 20 ft T-shaped Loop road landscaped island cul-de-sac turnaround

Figure 1.3.2-25 Four Turnaround Options for Residential Streets
(Source: Schueler, 1995)

Stormwater Site Design Practice #13:

Create Parking Lot Stormwater "Islands"

Reduction of Impervious Cover

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

KEY BENEFITS	USING THIS PRACTICE
• Reduces the amount of impervious cover and associated runoff and pollutants generated • Provides an opportunity for the siting of structural control facilities • Trees in parking lots provide shading for cars and are more visually appealing	☑ Integrate porous areas such as landscaped islands, swales, filter strips and bioretention areas in a parking lot design.

Discussion

Parking lots should be designed with landscaped stormwater management "islands" which reduce the overall impervious cover of the lot as well as provide for runoff treatment and control in stormwater facilities.

When possible, expanses of parking should be broken up with landscaped islands which include shade trees and shrubs. Fewer large islands will sustain healthy trees better than more numerous very small islands. The most effective solutions in designing for tree roots in parking lots is to use a long planting strip at least 8 feet wide, constructed with sub-surface drainage and compaction resistant soil.

Structural control facilities such as filter strips, dry swales and bioretention areas can be incorporated into parking lot islands. Stormwater is directed into these landscaped areas and temporarily detained. The runoff then flows through or filters down through the bed of the facility and is infiltrated into the subsurface or collected for discharge into a stream or another stormwater facility. These facilities can be attractively integrated into landscaped areas and can be maintained by commercial landscaping firms. For detailed design specifications of filter strips, enhanced swales and bioretention areas, refer to Chapter 5.

Figure 1.3.2-26 Parking Lot Stormwater "Island"

1.3.2.4 Utilization of Natural Features for Stormwater Management

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

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

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

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

The following pages cover each practice in more detail.

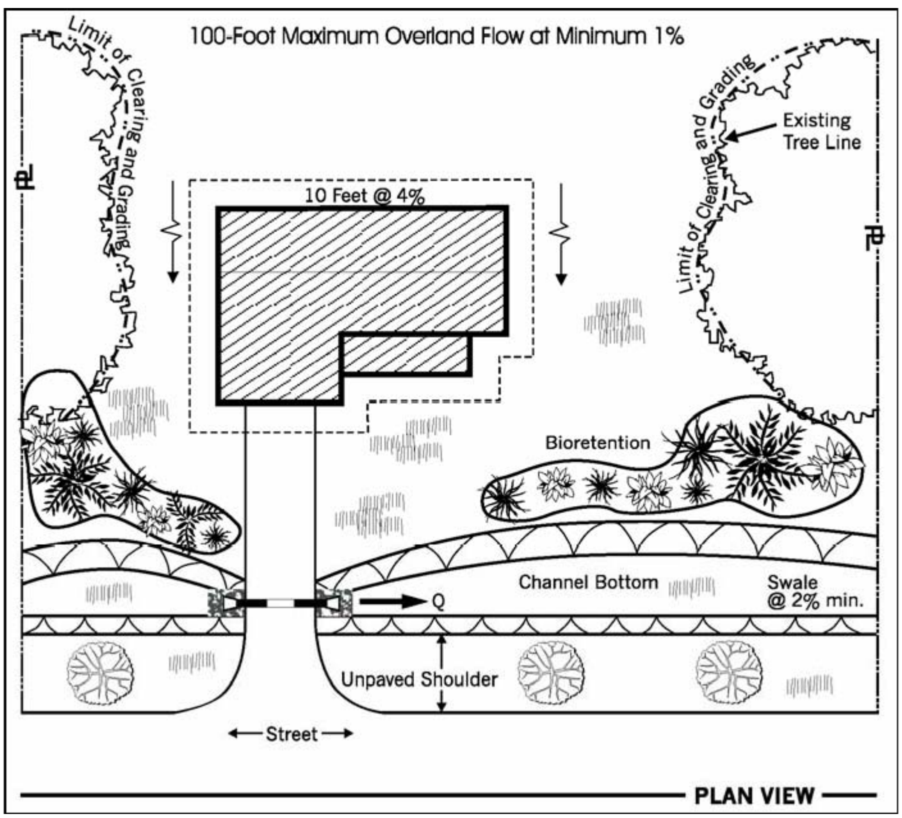


Figure 1.3.2-27 Residential Site Design Using Natural Features for Stormwater Management
(Source: Prince George's County, MD, 1999)

Use Buffers and Undisturbed Areas

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

KEY BENEFITS	USING THIS PRACTICE
• Riparian buffers and undisturbed vegetated areas can be used to filter and infiltrate storm water runoff • Natural depressions can provide inexpensive storage and detention of storm water flows • A storm water site design credit can be taken if allowed by the local review authority	☑ Direct runoff towards buffers and undisturbed areas using a level spreader to ensure sheet flow ☑ Utilize natural depressions for runoff storage

Discussion

Runoff can be directed towards riparian buffers and other undisturbed natural areas delineated in the initial stages of site planning to infiltrate runoff, reduce runoff velocity and remove pollutants. Natural depressions can be used to temporarily store (detain) and infiltrate water, particularly in areas with permeable (hydrologic soil group A and B) soils.

The objective in utilizing natural areas for stormwater infiltration is to intercept runoff before it has become substantially concentrated and then distribute this flow evenly (as sheet flow) to the buffer or natural area. This can typically be accomplished using a level spreader, as seen in Figure 1.3.2-28. A mechanism for the bypass of higher flow events should be provided to reduce erosion or damage to a buffer or undisturbed natural area.

Carefully constructed berms can be placed around natural depressions and below undisturbed vegetated areas with pervious soils to provide for additional runoff storage and/or infiltration of flows. See the section on bioretention areas as a stormwater control with a similar goal.

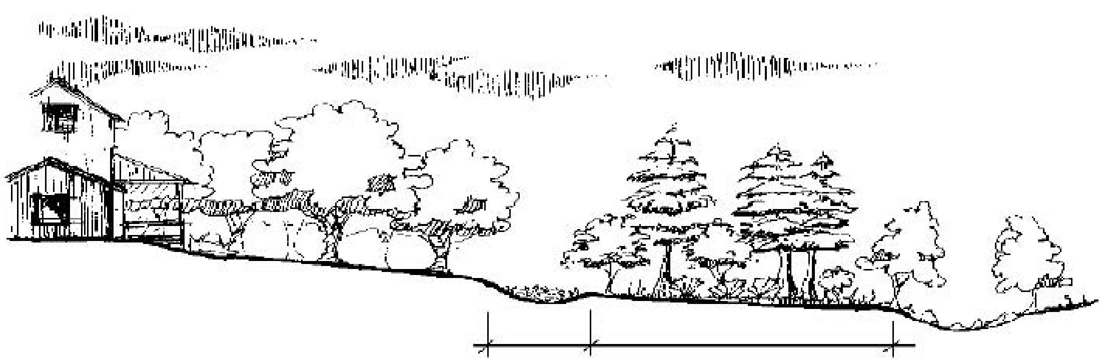


Figure 1.3.2-28 Use of a Level Spreader with a Riparian Buffer
(Adapted from NCDENR, 1998)

Stormwater Site Design Practice #15:

Use Natural Drainageways Instead of Storm Sewers

Description: The natural drainage paths of a site can be used instead of constructing underground storm sewers or concrete open channels.

KEY BENEFITS	USING THIS PRACTICE
• Use of natural drainageways reduces the cost of constructing storm sewers or other conveyances, and may reduce the need for land disturbance and grading • Natural drainage paths are less hydraulically efficient than man-made conveyances, resulting in longer travel times and lower peak discharges • Can be combined with buffer systems to allow for storm water filtration and infiltration	☑ Preserve natural flow paths in the site design ☑ Direct runoff to natural drainageways, ensuring peak flows and velocities will not cause channel erosion

Discussion

Structural drainage systems and storm sewers are designed to be hydraulically efficient in removing stormwater from a site; however, in doing so, these systems tend to increase peak runoff discharges, flow velocities and the delivery of pollutants to downstream waters. An alternative is the use of natural drainageways and vegetated swales (where slopes and soils permit) to carry stormwater flows to their natural outlets, particularly for low-density development and residential subdivisions.

The use of natural open channels (see Figure 1.3.2-29) allows for more storage of stormwater flows on-site, lower stormwater peak flows, a reduction in erosive runoff velocities, infiltration of a portion of the runoff volume, and the capture and treatment of stormwater pollutants. It is critical that natural drainageways be protected from higher post-development flows by applying downstream streambank protection methods (including the SP_v criteria) to prevent erosion and degradation.

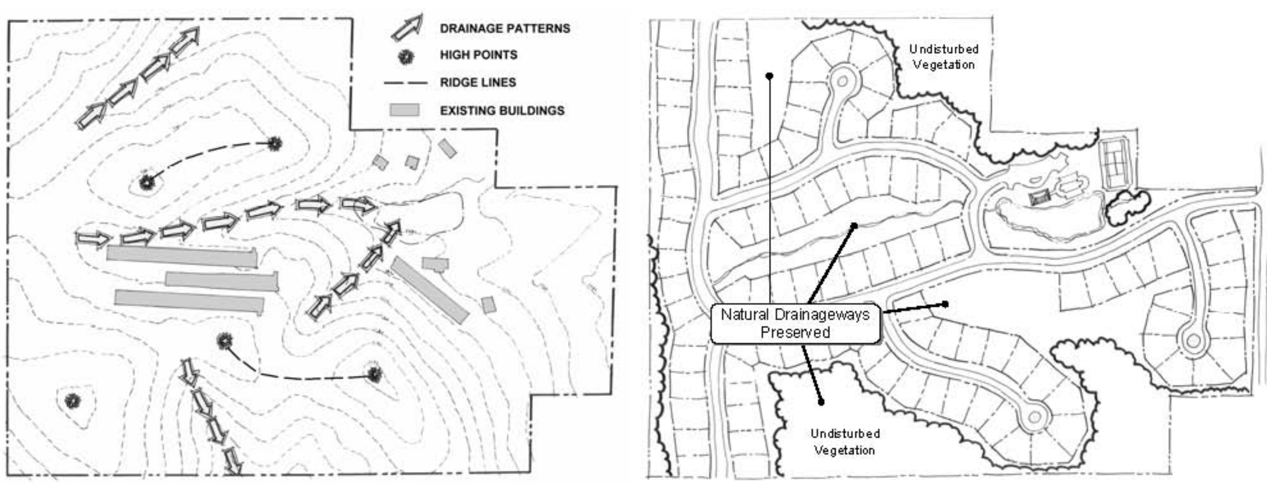


Figure 1.3.2-29 Example of a Subdivision Using Natural Drainageways for Stormwater Conveyance and Management

Stormwater Site Design Practice #16: **Utilization of Natural Features for Storm Water Management**

Use Vegetated Swales Instead of Curb and Gutter

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

KEY BENEFITS	USING THIS PRACTICE
• Reduces the cost of road and storm sewer construction • Provides for some runoff storage and infiltration, as well as treatment of storm water • A storm water site design reduction credit can be taken if allowed by the local review authority	☑ Use vegetated open channels (enhanced wet or dry swales or grass channels) in place of curb and gutter to convey and treat storm water runoff

Discussion

Curb and gutter and storm drain systems allow for quicker transport of stormwater from a site to a drainageway, which results in increased peak flow and flood volumes and reduced runoff infiltration. Curb and gutter systems also do not provide treatment of stormwater that is often polluted from vehicle emissions, pet waste, lawn runoff and litter.

Open vegetated channels along a roadway (see Figure 1.3.2-30) remove pollutants by allowing infiltration and filtering to occur, unlike curb and gutter systems which move water with virtually no treatment. Older roadside ditches which have not been maintained suffer from erosion, standing water, and break up of the road edge. Grass channels and enhanced dry swales are two alternatives when properly installed and maintained under the right site conditions, are excellent methods for treating stormwater on-site. In addition, open vegetated channels can be less expensive to install than curb and gutter systems. Further design information and specifications for grass channels/enhanced swales can be found in Chapter 5.

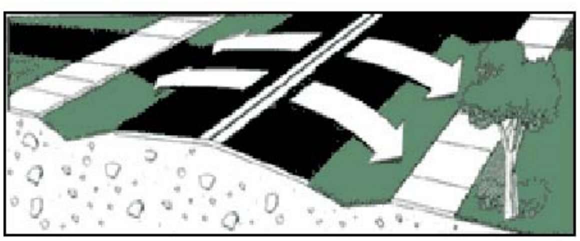


Figure 1.3.2-30 Using Vegetated Swales Instead of Curb and Gutter

Stormwater Site Design Practice #17:

Drain Runoff to Pervious Areas

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

KEY BENEFITS	USING THIS PRACTICE
• Sending runoff to pervious vegetated areas increases overland flow time and reduces peak flows • Vegetated areas can often filter and infiltrate storm water runoff • A stormwater site design credit can be taken if allowed by the local review authority	Minimize directly connected impervious areas and drain runoff as sheet flow to pervious vegetated areas

Discussion

Stormwater quantity and quality benefits can be achieved by routing the runoff from impervious areas to pervious areas such as lawns, landscaping, filter strips and vegetated channels. Much like the use of undisturbed buffers and natural areas (Stormwater Site Design Practice #14), revegetated areas such as lawns and engineered filter strips and vegetated channels can act as biofilters for stormwater runoff and provide for infiltration in pervious (hydrologic group A and B) soils. In this way, the runoff is "disconnected" from a hydraulically efficient structural conveyance such as a curb and gutter or storm drain system.

Some of the methods for disconnecting impervious areas include:

- Designing roof drains to flow to vegetated areas or infiltration areas
- Directing flow from paved areas such as driveways to stabilized vegetated areas
- Breaking up flow directions from large paved surfaces (see Figure 1.3.2-31)
- Carefully locating impervious areas and grading landscaped areas to achieve sheet flow runoff to the vegetated pervious areas

For maximum benefit, runoff from impervious areas to vegetated areas must occur as sheet flow and vegetation must be stabilized. See Chapter 5 for more design information and specifications on filter strips and vegetated channels.

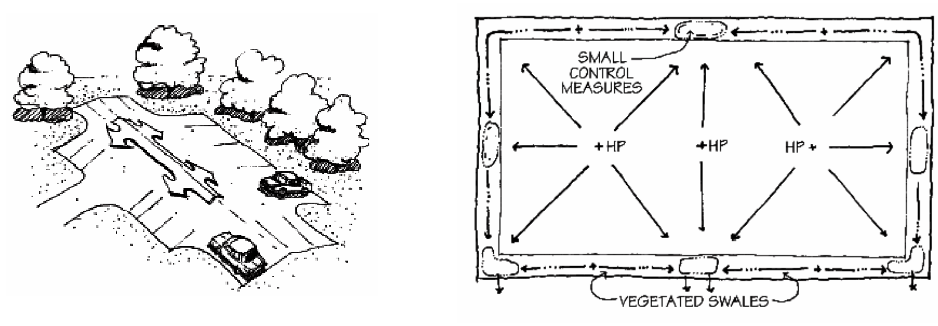


Figure 1.3.2-31 Design Paved Surfaces to Disperse Flow to Vegetated Areas
Source: NCDENR, 1998

1.3.3 Stormwater *Site Design Examples*

1.3.3.1 Residential Subdivision Example 1

A typical residential subdivision design on a parcel is shown in Figure 1.3.3-1 (a). The entire parcel except for the subdivision amenity area (clubhouse and tennis courts) is used for lots. The entire site is cleared and mass graded, and no attempt is made to fit the road layout to the existing topography. Because of the clearing and grading, all of the existing tree-cover, vegetation and topsoil are removed dramatically altering both the natural hydrology and drainage of the site. The wide residential streets create unnecessary impervious cover and a curb and gutter system that carries stormwater flows to the storm sewer system. No provision for non-structural stormwater treatment is provided on the subdivision site.

A residential subdivision employing stormwater site design practices is presented in Figure 1.3.3-1 (b). This subdivision configuration preserves a quarter of the property as undisturbed open space and vegetation. The road layout is designed to fit the topography of the parcel, following the high points and ridgelines. The natural drainage patterns of the site are preserved and are utilized to provide natural stormwater treatment and conveyance. Narrower streets reduce impervious cover and grass channels provide for treatment and conveyance of roadway and driveway runoff. Landscaped islands at the ends of cul-de-sacs also reduce impervious cover and provide stormwater treatment functions. Where possible, constructing and building homes, only the building envelopes of the individual lots are cleared and graded, further preserving the natural hydrology of the site.

1.3.3.2 Residential Subdivision Example 2

Another typical residential subdivision design is shown in Figure 1.3.3-2 (a). Most of this site is cleared and mass graded, with the exception of a small riparian buffer along the large stream at the right boundary of the property. Almost no buffer was provided along the small stream that runs through the middle of the property. In fact, areas within the 100-year floodplain were cleared and filled for home sites. As is typical in many subdivision designs, this one has wide streets for on-street parking and large cul-desacs.

The stormwater site design subdivision can be seen in Figure 1.3.3-2 (b). This subdivision layout was designed to conform to the natural terrain. The street pattern consists of a wider main thoroughfare, which winds through the subdivision along the ridgeline. Narrower loop roads branch off of the main road and utilize landscaped islands. Large riparian buffers are preserved along both the small and large streams. The total undisturbed conservation area is close to one-third of the site.

1.3.3.3 Commercial Development Example

Figure 1.3.3-3 (a) shows a typical commercial development containing a supermarket, drugstore, smaller shops and a restaurant on an outlot. The majority of the parcel is a concentrated parking lot area. The only pervious area is a small replanted vegetation area acting as a buffer between the shopping center and adjacent land uses. Stormwater quality and quantity control are provided by a wet extended detention pond in the corner of the parcel.

An stormwater site design commercial development can be seen in Figure 1.3.3-3 (b). Here the retail buildings are dispersed on the property, providing more of an “urban village” feel with pedestrian access between the buildings. The parking is broken up, and bioretention areas for stormwater treatment are built into parking lot islands. A large bioretention area which serves as open green space is located at the main entrance to the shopping center. A larger undisturbed buffer has been preserved on the site. Because the bioretention areas and buffer provide water quality treatment, only a dry extended detention basin is needed for water quantity control.

1.3.3.4 Office Park Example

An office park with a conventional design is shown in Figure 1.3.3-4 (a). Here the site has been graded to fit the building layout and parking area. All of the vegetated areas of this site are replanted areas.

The site design layout, presented in Figure 1.3.3-4 (b), preserves undisturbed vegetated buffers and open space areas on the site. Both the parking areas and buildings have been designed to fit the natural terrain of the site. In addition, a modular porous paver system is used for the overflow parking areas.

Figure 1.3.3-1 Comparison of a Traditional Residential Subdivision Design (above) with an Innovative Site Plan Developed Using Stormwater Site Design Practices (below).

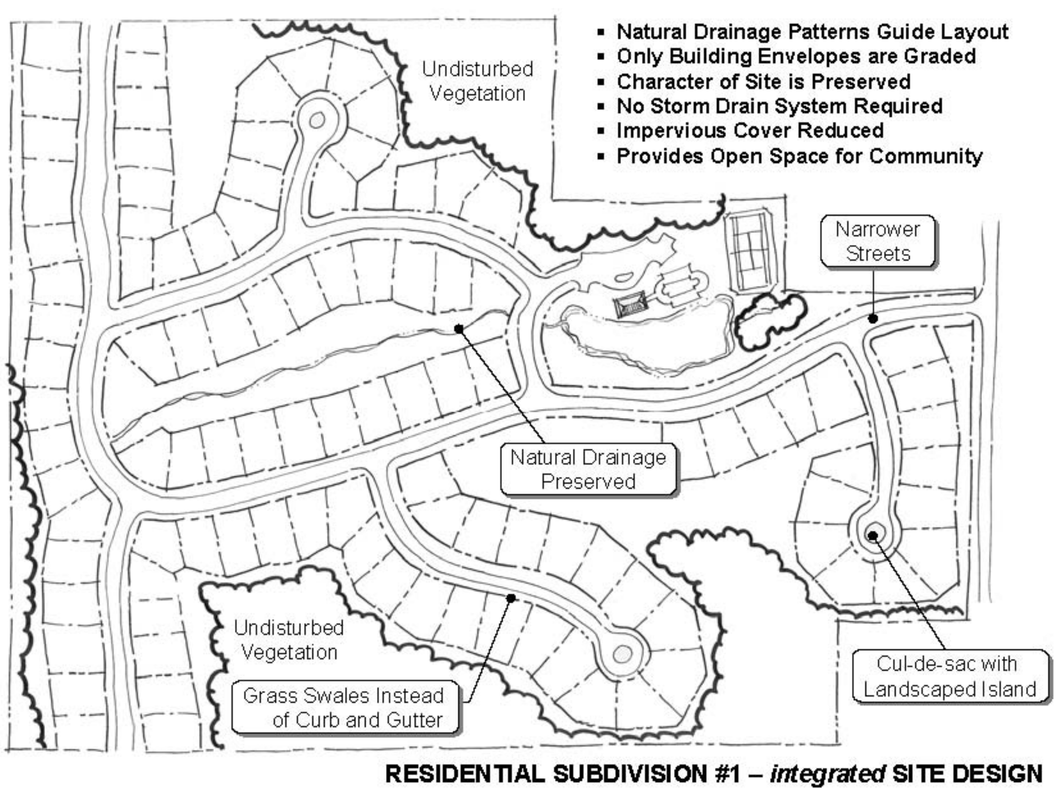
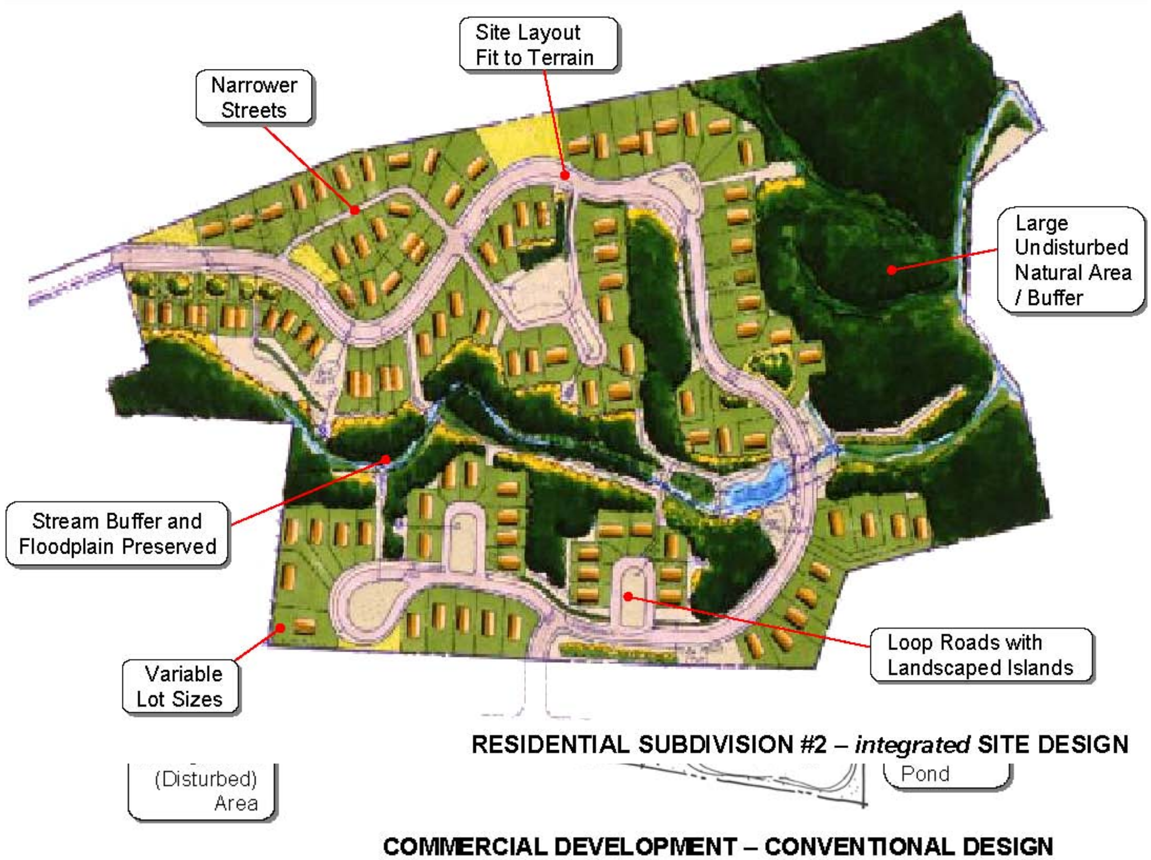


Figure 1.3.3-2 Comparison of a Traditional Residential Subdivision Design (above) with an Innovative Site Plan Developed Using Stormwater Site Design Practices (below).



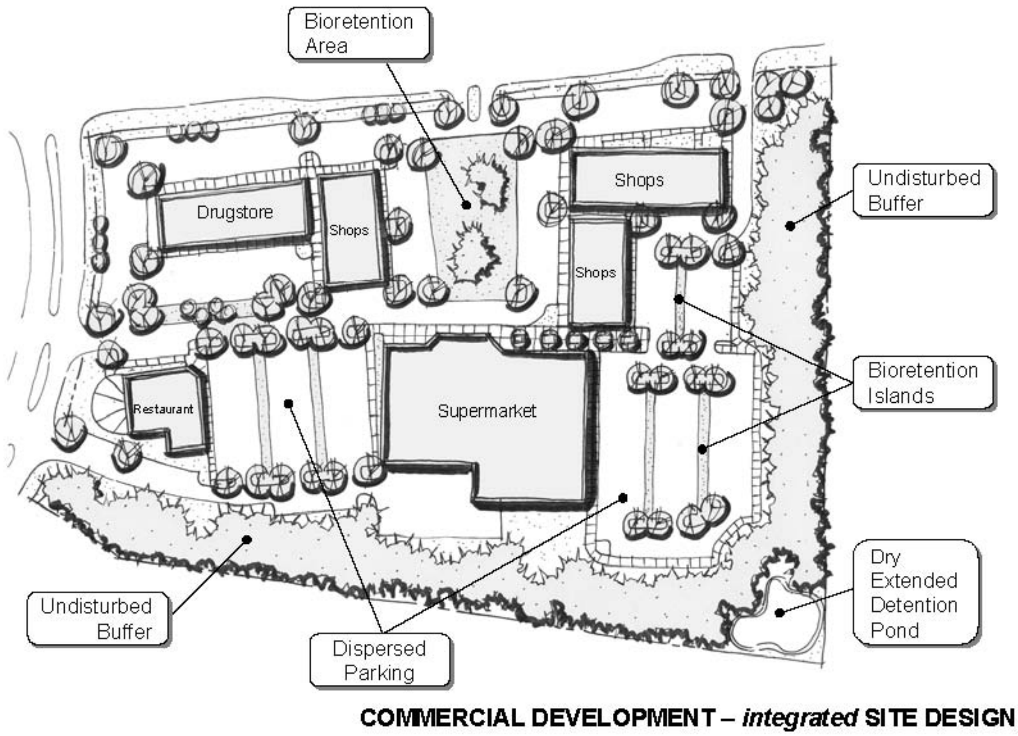
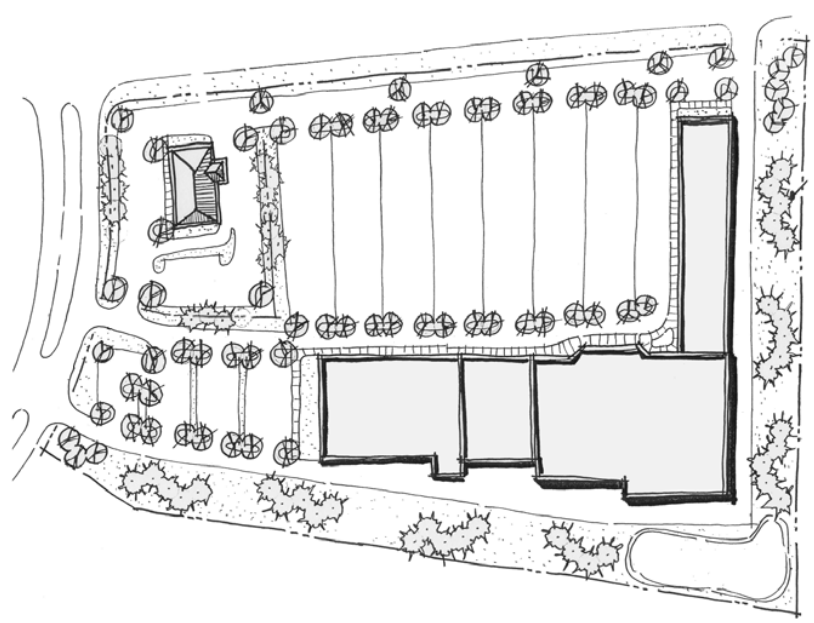


Figure 1.3.3-3 Comparison of a Traditional Commercial Development (above) with an Innovative Site Plan Developed Using Stormwater Site Design Practices (below).



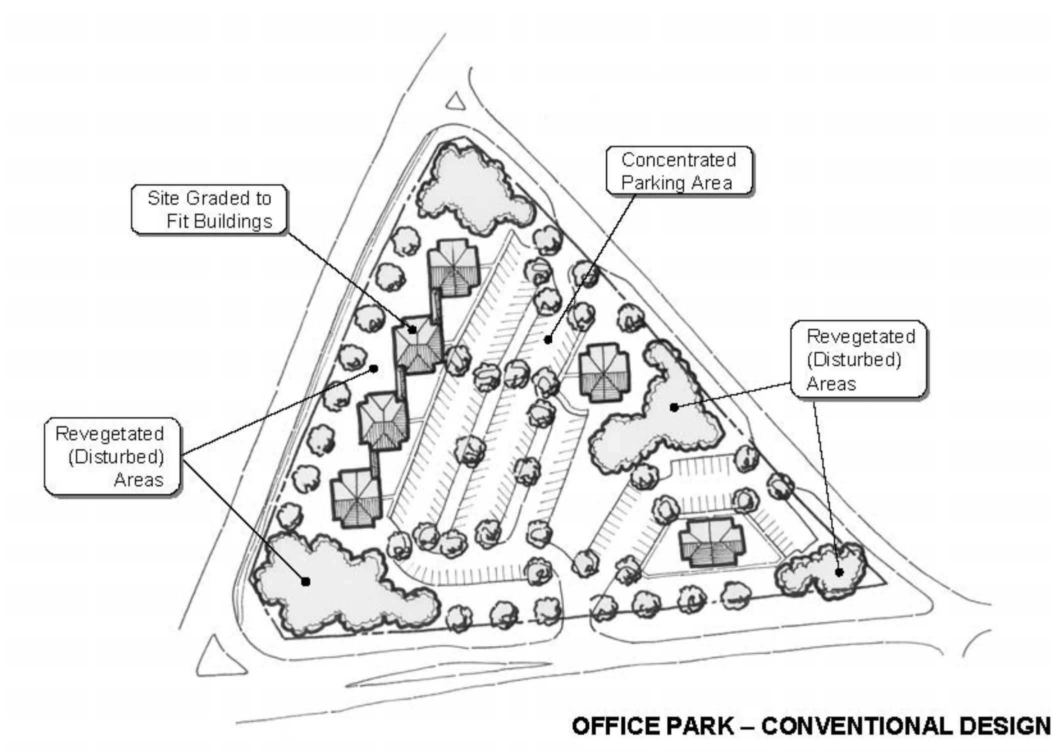
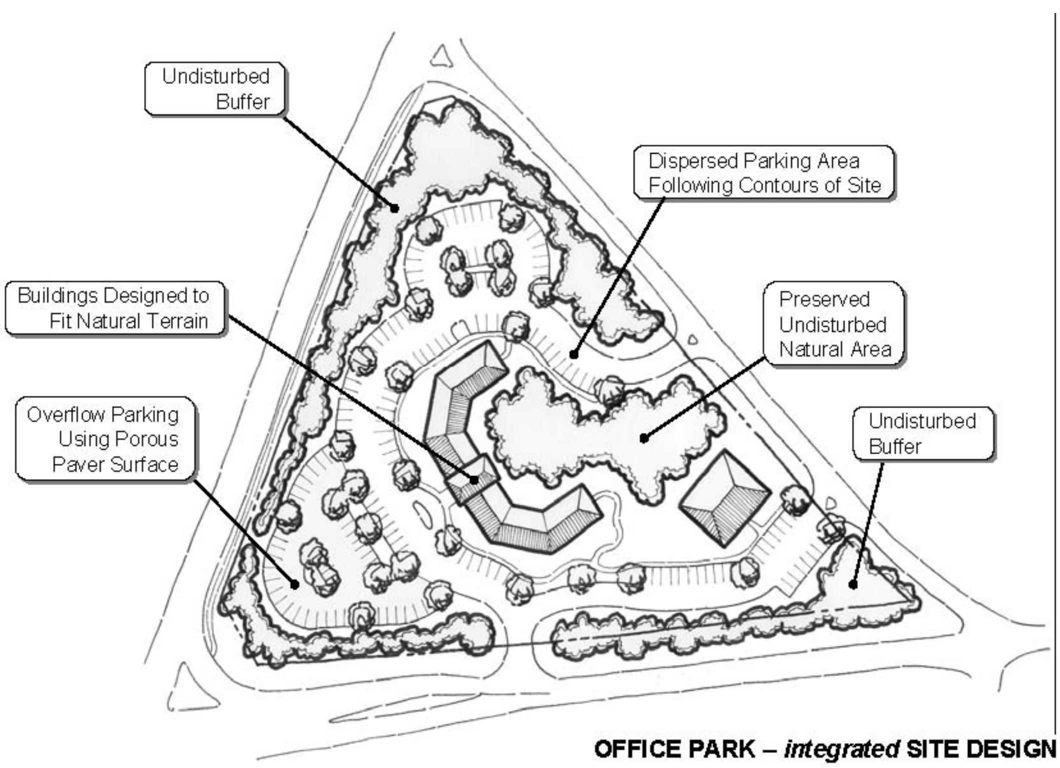


Figure 1.3.3-4 Comparison of a Traditional Office Park Design (above) with an Innovative Site Plan Developed Using Stormwater Site Design Practices (below).



Section 1.4 Stormwater Controls

1.4.1 Introduction

The impacts of stormwater runoff from development cannot be completely mitigated by land use and nonstructural approaches. Therefore, a community must develop a program to require the use of stormwater control measures on new development and redevelopment sites. Stormwater controls (sometimes referred to as *best management practices* or *BMPs*) are constructed stormwater management facilities designed to treat stormwater runoff and/or mitigate the effects of increased stormwater runoff peak rate, volume, and velocity due to urbanization.

Chapter 2 recommends a number of stormwater controls that can be used for meeting the stormwater management design approach including very specific performance and design criteria. The next several pages provide a brief overview of the range of stormwater controls recommended for use. Clearly not every control is applicable for every site or goal.

1.4.2 Recommended Stormwater Control Practices

<u>Bioretention Areas</u>

- Bioretention areas are shallow stormwater basins or landscaped areas that utilize engineered soils and vegetation to capture and treat stormwater runoff. Runoff may be returned to the conveyance system, or allowed to fully or partially infiltrate into the soil.

<u>Channels</u>

- *Enhanced Swale:* A vegetated open channel that is explicitly designed and constructed to capture and treat stormwater runoff within wet or dry cells formed by check dams or other means.
- *Grass Channel:* A vegetated open channel designed to filter stormwater runoff and meet velocity targets for the water quality and streambank protection design storm events.
- *Open Conveyance Channel:* Includes such conveyance systems as drainage ditches, grass channels, dry and wet enhanced swales, riprap channels, and concrete channels.

<u>Chemical Treatment</u>

- *Alum Treatment System:* This chemical treatment provides for the injection of liquid alum into stormwater runoff on a flow-weighted basis during rain events as it enters a settling basin. The alum precipitate or 'floc' that is formed during coagulation combines with nutrients, suspended solids, and heavy metals and settles in the settling basin.

<u>Conveyance Components</u>

- *Culverts:* Typically, short, closed (covered) conduits that convey stormwater runoff under an embankment, usually a roadway. The primary purpose of a culvert is to convey surface water, but it may also be used to restrict flow and reduce downstream peak flows.
- *Energy Dissipators:* Energy dissipaters are engineered devices such as riprap or concrete baffles placed at the outlet of a stormwater conveyance for the purpose of reducing the velocity, energy, and turbulence of the discharged flow.
- *Inlets/Street Gutters:* Drainage elements that remove runoff from sidewalks, streets, and sumps for public safety purposes and function to input stormwater to the storm drain pipe systems.
- *Pipe Systems:* A branching system of closed conduits that accumulate stormwater runoff and convey it to an open channel, natural stream, or storage facility.

<u>Detention</u>

- **Dry Detention:* Dry detention basins are surface storage basins or facilities typically designed to provide water quantity control through detention or extended detention of stormwater runoff.

- **Extended Dry Detention Basins:* Extended dry detention basins are surface storage basins or facilities that can be designed to provide water quality and quantity control through extended detention of stormwater runoff.

- *Multi-Purpose Detention Areas:* Multi-purpose detention areas are facilities designed primarily for another purpose, such as parking lots and rooftops, that can provide water quantity control through detention of stormwater runoff.
- *Underground Detention:* Underground detention storage is provided by underground tanks or vaults designed to provide water quantity control through detention and/or extended detention of stormwater runoff.

Filtration

- *Filter Strip:* Filter strips are uniformly graded and densely vegetated sections of land engineered and designed to treat runoff and remove pollutants through vegetative filtering and infiltration.
- *Organic Filter:* Organic filters are design variant of the surface sand filter using organic materials such as peat or compost in the filter media.
- *Planter Boxes:* Planter boxes are used on impervious surfaces to collect and detain/infiltrate rainfall and runoff. They usually contain growing plants.
- *Surface Sand Filter / Permanent Sand Filter:* Sand filters are multi-chamber structures designed to treat stormwater runoff through filtration, using a sand bed as the primary filter media. Filtered runoff may be returned to the conveyance system, or allowed to fully or partially infiltrate into the soil.
- *Underground Sand Filter:* The underground sand filter is a design variant of the surface sand filter located in an underground vault designed for high density land use where there is not enough space for a surface sand filter or other stormwater controls.

Hydrodynamic Devices

- *Gravity (Oil-Grit) Separator:* The gravity (oil-grit) separator is a hydrodynamic separation device designed to remove settleable solids, oil, grease, debris, and floatables from stormwater runoff through gravitational settling and trapping of pollutants.

Infiltration

- *Downspout Drywells:* Downspout Drywells are essentially perforated manholes, but they can be manufactured in various sizes. Located underground, they allow stormwater infiltration even in highly urbanized areas. They should be used in conjunction with some type of pretreatment devices where there are minimal risks of groundwater contamination.
- *Infiltration Trench:* Infiltration trenches are excavated trenches filled with stone aggregate used to capture and allow infiltration of stormwater runoff into the surrounding soils from the bottom and sides of the trench.
- *Soakage Trench:* Soakage trenches are a variation of infiltration trenches. Soakage trenches drain through a perforated pipe buried in gravel. They are used in highly impervious areas where conditions do not allow surface infiltration and where pollutant concentrations in runoff are minimal (i.e. non-industrial rooftops). They may be used in conjunction with other stormwater devices, such as draining downspouts or planter boxes.

*Ponds

There are two stormwater storage functions: detention and retention. Detention ponds are designed to store water and release it over time to empty the basin. Retention basins have a permanent pool (or micropool) of water. Some basins are designed to include both detention and retention. Runoff from each rain event is detained and treated in the pool. Pond design variants include:

- Micropool Extended Detention Pond
- Multiple Pond Systems
- Wet Extended Detention Pond
- Wet Pond

Porous Surfaces

- *Green Roofs:* A green roof uses a small amount of substrate over an impermeable membrane to support a covering of plants. The green roof slows down runoff from the otherwise impervious roof surface as well as moderating rooftop temperatures. With the right plants, a green roof will also provide aesthetic or habitat benefits. Green roofs have been used in Europe for decades.
- *Modular Porous Paver Systems:* Modular porous paver systems are pavement surfaces composed of structural units with void areas that are filled with pervious materals such as sand or grass turf. Porous pavers are installed over a gravel base course to provide storage as runoff infiltrates through the porous paver system into underlying permeable soils.
- *Porous Concrete:* Porous concrete is the term for a mixture of coarse aggregate, Portland cement, and water that allows for rapid infiltration of water and overlays a stone aggregate reservoir. The reservoir provides temporary storage as runoff infiltrates into underlying permeable soils and/or out

through an underdrain system.

Proprietary Structural Controls

There are numerous manufactured structural control systems available from commercial vendors designed to treat stormwater runoff and/or provide water quantity control.

Re-Use

- *Rain Harvesting (Tanks/Barrels):* A rain harvesting system is a container or system designed to capture and store rainwater discharged from a roof. The rain harvesting system consists of a storage container, a downspout diversion, a sealed lid, and an overflow system. Typical rain harvesting systems hold between 50 and 500 gallons of water, and may work in series to provide larger volumes of storage. For larger roof tops an underground storage tank and pump system can provide water for irrigation purposes on site.

Wetlands

- **Stormwater Wetlands:* Stormwater wetlands are constructed wetland systems used for stormwater management. Stormwater wetlands consist of a combination of shallow marsh areas, open water areas, and semi-wet areas above the permanent water surface. Wetland design variants include:
    - Extended Detention Shallow Wetland
    - Pocket Wetland
    - Pond/Wetland Systems
    - Shallow Wetland

- *Submerged Gravel Wetlands:* Submerged gravel wetlands are also known as subsurface flow wetlands and consist of one or more cells filled with crushed rock designed to support wetland plants. Stormwater runoff flows subsurface through the root zone of the constructed wetland where pollutant removal takes place.

Consideration must be given in the design of stormwater ponds, wetlands, and detention basins to minimize potential mosquito breeding areas. This can be accomplished in a variety of ways including aquatic and chemical techniques which should be utilized as appropriate for the situation. This is a particularly important issue in light of recent occurrences of the West Nile virus transmitted by mosquitoes.

1.4.3 Suitability of Stormwater Controls to Meet Stormwater Management Goals

Table 1.4-1 summarizes the stormwater management suitability of the various stormwater controls in addressing the Stormwater Management Design Approach. Given that some stormwater controls cannot alone meet all of the design requirements, typically two or more controls are used in series to form what is known as a stormwater “treatment train.” Chapter 5 provides guidance on the use of a treatment train as well as how to calculate the pollutant removal efficiency for stormwater controls in series. Chapter 5 also provides guidance for choosing the appropriate stormwater control(s) for a site as well as the basic considerations and limitations on the use of a particular stormwater control.

Table 1.4-1 Suitability of Stormwater Controls to Meet Stormwater Management Design Approach

Category	On-Site Stormwater Controls	Water Quality Protection	Streambank Protection	On-Site Flood Control	Downstream Flood Control
Bioretention Areas	Bioretention Areas	**P**	**S**	**-**	**-**
Channels	Enhanced Swales	**P**	**S**	**S**	**S**
	Channels, Grass	**S**	**S**	**P**	**-**
	Channels, Open	**-**	**-**	**P**	**S**
Chemical Treatment	Alum Treatment System	**S**	**-**	**-**	**-**
Conveyance Components	Culverts	**-**	**-**	**P**	**S**
	Energy Dissipation	**-**	**P**	**S**	**S**
	Inlets/Street Gutters	**-**	**-**	**P**	**-**
	Pipe Systems	**-**	**P**	**P**	**S**
Detention	Detention, Dry	**S**	**P**	**P**	**P**
	Detention, Extended Dry	**S**	**P**	**P**	**P**
	Detention, Multi-purpose Areas	**S**	**P**	**P**	**P**
	Detention, Underground	**S**	**P**	**P**	**P**
Filtration	Filter Strips	**S**	**-**	**-**	**-**
	Organic Filters	**P**	**-**	**-**	**-**
	Planter Boxes	**P**	**-**	**-**	**-**
	Sand Filters, Surface/Perimeter	**P**	**S**	**-**	**-**
	Sand Filters, Underground	**S**	**-**	**-**	**-**
Hydrodynamic Devices	Gravity (Oil-Grit) Separator	**S**	**-**	**-**	**-**
Infiltration	Downspout Drywell	**P**	**-**	**-**	**-**
	Infiltration Trenches	**P**	**S**	**-**	**-**
	Soakage Trenches	**P**	**-**	**-**	**-**
Ponds	Ponds, Stormwater	**P**	**P**	**P**	**P**
Porous Surfaces	Green Roof	**P**	**S**	**-**	**-**
	Modular Porous Paver Systems	**S**	**S**	**-**	**-**
	Porous Concrete	**S**	**S**	**-**	**-**
Proprietary Systems	Proprietary Systems *****	**S**	**S**	**S**	**S**
Re-Use	Rain Barrels	**P**	**-**	**-**	**-**
Wetlands	Wetlands, Stormwater	**P**	**P**	**P**	**P**
	Wetlands, Submerged Gravel	**P**	**P**	**S**	**-**

P = **Primary Control:** Able to meet design criterion if properly designed, constructed and maintained.

S = **Secondary Control:** May partially meet design criteria. May be a Primary Control but designated as a Secondary due to other considerations.

- = For Water Quality Protection, recommended for limited use in approved community-designated areas. Not typically used or able to meet design criterion.

***** = The application and performance of proprietary commercial devices and systems must be provided by the manufacturer and should be verified by independent third-party sources and data.

Pre-Construction Activity Inspection

LP# _______ Insp.# ______________

www.murfreesborotn.gov/government

APPENDIX A

Name/Developer: ________________________________ Phase/Section: __________ File No. __________

Contractor: ________________________________ On-site EPSC rep.: ____________________________

Pre-Construction Meeting; date: ___/____/___

Receiving stream: --

[ ]Yes [ ]No SWPPP has been prepared by qualified person(s).
[ ]Yes [ ]No Discharge into or above impaired waters?
[ ]Yes [ ]No TDEC CGP siltation-impairment requirements apply.
[ ]Yes [ ]No TDEC buffer zone requirements applicable.
[ ]Yes [ ]No TDEC ARAP applicable. [ ] Obtained
[ ]Yes [ ]No City's water quality protection area applicable.
[ ]Yes [ ]No Epsc rep. has attended [ ]State [ ]City epsc training.
[ ]Yes [ ]No Operator explained how topsoil will be managed.
[ ]Yes [ ]No Wood will be mulched and [ ] used for epsc.

[ ]Yes [ ]No TMDL applies. Parameter(s): -----------------------
[ ]Yes [ ]No [ ]NA SWPPP provides record of TMDL eligibility.
[ ]Yes [ ]No [ ]NA Steep slope protections identified and planned.
[ ]Yes [ ]No [ ]NA S/water run-on will be diverted from active construction.

Responsible parties issues

[ ]Yes [ ]No Multiple contractors on-site affecting storm water runoff:
[ ]Electric [ ]Gas [ ]W/S [ ]Cable/Optic [ ]Epsc specialist
[ ]Yes [ ]No SWPPP identifies when contractors are responsible for epsc.

Inspections

[ ]Yes [ ]No EPSC rep. explained inspection protocol and frequency.
[ ]Yes [ ]No EPSC rep. showed and explained inspection log and forms.
[ ]Yes [ ]No City's inspection schedule and personnel identified.

Pre-Con EPSC Inspection

[ ]Yes [ ]No SWPPP is present on site.
[ ]Yes [ ]No EPSC representative present.
[ ]Yes [ ]No Place for posting of permits is identified.
[ ]Yes [ ]No Construction exit (1½-2½" stone & geotextile) installed.
[ ]Yes [ ]No Silt fence or other perimeter control placed on contour.
[ ]Yes [ ]No Silt fence/perimeter control properly staked and buried.
[ ]Yes [ ]No [ ]NA Sediment traps properly located and installed.
[ ]Yes [ ]No [ ]NA Pond is located, sized, and installation is scheduled.
[ ]Yes [ ]No [ ]NA Riparian buffer/water quality protection area is marked.

The undersigned certify they have discussed erosion prevention and sediment controls for the project referenced above. The project representative certifies understanding of the Murfreesboro land disturbance permitting requirements and that failure to comply may result in compliance orders, penalties, and/or stop work orders until compliance is accomplished.

Project rep.: ____________________________________ Title (if applicable): ________________________

Inspector: ____________________________________ Date and Time: ___/____/___ at ____ : ____ am/pm

Original – Owner/Developer/Responsible Party Yellow – City Pink – On-site representative

PreCon 11-2005

Table of Murfreesboro and Tennessee Permit Requirements

Listed below are key provisions of Murfreesboro City Code and regulations and State of Tennessee requirements. Additional detail may be found at www.murfreesborotn.gov/government/water_sewer/stormwater.htm and at www.state.tn.us/ environment/permits/conststrm.php. The abbreviation *epsc* refers erosion prevention and sediment controls. Inspection no. is assigned by the inspector in this format: yyyymmdd##, where year, month and day are followed by 01 for the inspector's first inspection record of that day, 02 for the second, etc. Ex., the first inspection of July 15, 2005, would be 2005071501.

	City Code	State CGP	Condition/Requirement
☐	27 ½-7(e)	3.1.1	SWPPP must be prepared by person having working knowledge of epsc, such as CPESC certification. Calculations for sediment ponds shall be done by registered P.E. or landscape architect.
☐	--	3.3.2	The following to be posted at site entrance: State NOC with pmt tracking no.; name of owner, operator or local contact person; description of project; location of SWPPP (should be available at site)
☐	--	3.5.8.1	Inspectors on state-regulated projects must have completed the TDEC/UT epsc "Fundamentals" course or an equivalent course. Effective date, June, 2007. Copy of the certification should be kept on site.
☐	--	3.1	The SWPPP developed by the initial permittee (typically owner/developer) must assign responsibilities to various operators (typically contractors) and coordinate all BMPs at the construction site.
☐	27 ½-5 (h)	3.5.8.2.	The Permittee shall conduct and record regular inspections of epsc for the purpose of preventing Erosion and transport of Sediment off the property to stormwater drainage system and to waters of the state. Schedule should be twice per week, at least 72 hours apart. Permittee must keep record book. Inspections must address storm water drainage system; repairs & remedies of epsc; whether construction is in compliance with approved plans; notes re: variations from approved plans or specs; and violations. State requires that inspections address disturbed areas; epsc & their functionality; structural controls; materials storage areas; vehicle exits; outfalls and discharge points for evidence of sediment loss. Records shall include name and title of inspector(s), dates; major observations related to SWPPP implementation; places where sediment has left site and where epsc has/have failed or are inadequate.
☐	Priority Construction Activity	4.4.1	Impaired waters: Sinking Creek, Lytle Creek, Dry Branch, Bear Branch, unnamed trib to Bushman Creek, West Fork Stones River downstream of Lytle Creek (just south of Manson Pike), WFSR upstream of Middle Fork SR. For these watersheds, epsc designed to function in event of a 5-year, 24-hour storm. For drainage areas of five acres or more, sediment basin to contain runoff from a 5-year, 24-hour rain event; or equivalent control measures. Weekly epsc inspections to be certified on appendix C of the state's CGP. Records kept on site.
☐	27 ½-7(e)(16)	3.5.3.1 d)	Clean-up of sediment that escapes site, prior to reaching waters of the state
☐	EPSC Manual	3.5.3.2	Vegetative practices: Use of mulch [MU]; temporary vegetation [TS]; erosion control blanket or matting [MA]; sod [SO]; permanent vegetation [PS]; polyacrlamide [PAM]. Notes: MA to be used where slope is > 2.5:1 or in high flow channels (> 5 fps).
☐	EPSC Manual	3.5.3.3	Structural practices: Check dam [CD]; construction exit [CE]; construction road stabilization [CRS]; dewatering structure [DW]; diversion [DI]; filter ring [FR]; gabion [GA]; geotextile [GE]; gradient treatment [GT]; riprap [RR]; sediment basin with wet pool and riser outlet[SB]; sediment trap [ST]; silt fence on contour, well entrenched and well staked, max. drainage area ¼ acre for every 100 feet [SF]; slope drain [SD]; storm drain inlet protection [IP]; storm drain outlet protection [OP]; surface roughening by mechanized equip. to provide rough texture to soils at final grade [SR]; stream diversion channel [SDC] for utility crossings, etc. (ARAP required); temporary stream crossing [TSC] (ARAP required); bioengineering stream bank stabilization [SBS].
☐	--	State rule 1200-4-7	Persons who conduct any activity that involves the alteration of waters of the State require a state and possibly a federal permit. http://www.state.tn.us/environment/permits/arap.php
☐	--	3.5.10	The state-required SWPPP must include documentation supporting a determination of permit eligibility with regard to waters that have an approved TMDL for a pollutant of concern.

Land Disturbance Permits issued by Building and Codes Department contain the following statements:

1. Selection and installation of erosion prevention and sediment controls shall correspond to the EPSC/SWPPP plan submitted to the City as a part of the Land Disturbance Permit application and approved by the City Engineering Department.
2. Installation, inspections and maintenance of EPSC shall comply with requirements set forth in Murfreesboro City Code, with respect to planning and design, as listed at City Code Chapter 27 ½ - 7 (d); and with respect to inspections and frequency of inspections, as listed at City Code Chapter 27 ½ - 5 (h).
3. Installation and maintenance of EPSC shall be accomplished according to standard practice as described in the City-adopted "Tennessee Erosion Prevention and Sediment Control Handbook – A Guide for Protection of State Waters through the use of Best Management Practices during Land Disturbing Practices."

PreCon 11-2005

Construction Activity Inspection

LP# _______ Insp.# ______________

www.murfreesborotn.gov/government

APPENDIX B

Name/Location: ______________________________ Phase/Section: ______________ File No.: ____________

Contractor: _________________________________ On-site EPSC rep.: _______________________________

Date: ___________ Weather: [ ] Dry [ ] Wet Last Rainfall Date: _____________ Amount _______ in

Is rep. knowledgeable of [ ] SWPPP [ ] design EPSC [ ] inspection requirements [ ] maintenance requirements ?

General requirements & site conditions

[ ]Yes [ ]No SWPPP is present on site and up-to-date.
[ ]Yes [ ]No Epsc are installed according to SWPPP.
[ ]Yes [ ]No Logbook is present showing inspections & epsc repairs.
[ ]Yes [ ]No EPSC rep. has attended TDEC epsc class.

Inspections and recordkeeping

[ ]Yes [ ]No Frequency of inspections meets twice per week standard.
[ ]Yes [ ]No Inspections record epsc failures, inadequacies & repairs.
[ ]Yes [ ]No Log records dates of major grading, rainfall dates & totals.
[ ]Yes [ ]No Inspections include investigation of s/water drainage system.
[ ]Yes [ ]No Inspections include investigation of outfalls & discharge points.
[ ]Yes [ ]No TDEC weekly/quarterly insp. forms up to date & on site.
[ ]Yes [ ]No [ ]NA Records show changes to epsc from approved SWPPP.

Special issues

[ ]Yes [ ]No [ ]NA TDEC buffer zone is protected.
[ ]Yes [ ]No [ ]NA City's water quality protection area is protected.
[ ]Yes [ ]No [ ]NA Work regulated under state ARAP is in process.
[ ]Yes [ ]No [ ]NA Parties do not agree on particular epsc responsibilities.
[ ]Yes [ ]No [ ]NA Lots at final grade have been temporarily stabilized.
[ ]Yes [ ]No Site has been sufficiently stabilized; LDP can be terminated.

Performance bond issues

[ ]Yes [ ]No Stormwater conveyance systems _______ % complete.
[ ]Yes [ ]No Storm water conveyance system free of sediment.
[ ]Yes [ ]No Failure to install epsc: ________ % complete.
[ ]Yes [ ]No Record drawings of stormwater systems filed.

Inspector's comments

[ ]Yes [ ]No [ ]NA Discharge points contain sediment.
[ ]Yes [ ]No [ ]NA Sediment loss to stream evident.
[ ]Yes [ ]No [ ]NA Discharge causing in-stream color contrast.
[ ]Yes [ ]No [ ]NA Sediment has been removed from streets.

Erosion prevention and sediment controls

	Compliance		
EPSC	**NA**	**Y**	**N**
Removal of vegetative cover < ten days prior to grading	[ ]	[ ]	[ ]
Preconstruction epsc in place	[ ]	[ ]	[ ]
Construction exit to standard	[ ]	[ ]	[ ]
Inlet protections in place	[ ]	[ ]	[ ]
Temporary erosion control in areas un-worked for 15 days	[ ]	[ ]	[ ]
Epsc for stockpiled soils	[ ]	[ ]	[ ]
Silt fence maintained and at < 50% capacity	[ ]	[ ]	[ ]
Sediment controls maintained and at < 50% capacity	[ ]	[ ]	[ ]
Sediment traps located and constructed correctly.	[ ]	[ ]	[ ]
Sediment pond sized correctly.	[ ]	[ ]	[ ]
Sediment pond outlet structure	[ ]	[ ]	[ ]
Runoff is diverted around disturbed areas.	[ ]	[ ]	[ ]
Less than 50 acres is disturbed at one time (phasing).	[ ]	[ ]	[ ]
Slopes > 2.5:1 are stabilized with matting or e.c. blankets.	[ ]	[ ]	[ ]
Concentrated flow areas stabilized w/matting or blankets	[ ]	[ ]	[ ]
Muddy water from work areas treated prior to stream	[ ]	[ ]	[ ]

You are hereby given notice to correct circled items by ____/____/____, and epsc violations within ____ hours. Continued non-compliance may result in citation, civil penalty and/or stop work order. Inspector tel. no.: __________________________

Report rec'd by: ____ Title (if applicable): ___________________________

Inspector: ____ Date and Time: ___/____/___ at ____ : ____ am/pm

Original – Owner/Developer/Responsible Party Yellow – City Pink – On-site representative

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	City Code	State CGP	Condition/Requirement
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☐	--	3.5.8.1	Inspectors on state-regulated projects must have completed the TDEC/UT epsc "Fundamentals" course or an equivalent course. Effective date, June, 2007. An engineer or landscape architect who prepared the SWPPP may also conduct the required inspections. Copy of the certification should be kept on site.
☐	27 ½-5 (h)	3.5.8.2.	The Permittee shall conduct and record regular inspections of epsc for the purpose of preventing Erosion and transport of Sediment off the property to stormwater drainage system and to waters of the state. Inspections must address storm water drainage system; repairs & remedies of epsc; whether construction is in compliance with approved plans; notes re: variations from approved plans or specs; and violations. State CGP adds that inspections shall address disturbed areas; epsc and their functionality; structural controls; materials storage areas exposed to rainfall; vehicle exits; outfalls and discharge points for evidence of sediment loss. Records shall include name and title of inspector(s), dates; major observations related to SWPPP implementation; places where sediment has left site and where epsc has/have failed or are inadequate.
☐	27 ½-5 (h)(3)	3.5.8.2.	Permittee must inspect epsc at least ***twice per week***, at least 72 hours apart. Portions of site temporarily stabilized may be inspected at a once per month frequency, provided a written request with justification has been submitted to the local TDEC office. Permittee must keep record book.
☐	Priority Construction Activity	4.4.1	Impaired waters: Sinking Creek, Lytle Creek, Dry Branch, Bear Branch, unnamed trib to Bushman Creek, West Fork Stones River downstream of Lytle Creek (just south of Manson Pike), WFSR upstream of Middle Fork SR. For these watersheds, epsc designed to function in event of a 5-year, 24-hour storm. For drainage areas of five acres or more, sediment basin to contain runoff from a 5-year, 24-hour rain event; or equivalent control measures. Weekly epsc inspections to be certified on appendix C of the state's CGP. Records kept on site.
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Land Disturbance Permits issued by Building and Codes Department contain the following statements:

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5. Installation, inspections and maintenance of EPSC shall comply with requirements set forth in Murfreesboro City Code, with respect to planning and design, as listed at City Code Chapter 27 ½ - 7 (d); and with respect to inspections and frequency of inspections, as listed at City Code Chapter 27 ½ - 5 (h).
6. Installation and maintenance of EPSC shall be accomplished according to standard practice as described in the City-adopted "Tennessee Erosion Prevention and Sediment Control Handbook – A Guide for Protection of State Waters through the use of Best Management Practices during Land Disturbing Practices."

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Appendix C
WORKSHEETS AND CHECKLISTS

Table of Contents

Worksheet for Conceptual Stormwater Management Site Plan

	Included? Yes	Included? No	Comments
I. Review of **Stormwater Management Site Design Practices**			
A. **Conservation of Natural Features and Resources**			
Are there opportunities to:			
1. conserve undisturbed vegetation?	____	____	________________
2. conserve floodplains?..	____	____	________________
3. conserve steep slopes?..	____	____	________________
4. conserve natural drainageways?...............................	____	____	________________
5. conserve streams?	____	____	________________
6. conserve wetlands?...	____	____	________________
7. conserve other natural features?...............................	____	____	________________
8. conserve critical areas?..	____	____	________________
B. **Lower Impact Site Design Techniques**			
Are there opportunities to:			
1. reduce clearing and grading?....................................	____	____	________________
2. locate development in less sensitive areas?.............	____	____	________________
3. utilize open space development?	____	____	________________
5. utilize other techniques?..	____	____	________________
C. **Reduction of Impervious Cover**			
Are there opportunities to:			
1. reduce roadway lengths?	____	____	________________
2. reduce roadway widths?..	____	____	________________
3. reduce building footprints?	____	____	________________
4. reduce parking lots?	____	____	________________
5. utilize fewer or alternative cul-de-sacs?	____	____	________________
6. utilize pervious pavement?..	____	____	________________
7. utilize other reduction measures?	____	____	________________.
D. **Utilization of Natural Features for Storm Water Management**			
Are there opportunities to:			
1. utilize buffers?	____	____	________________
2. utilize undisturbed areas?...	____	____	________________
3. utilize natural drainageways vs storm drain systems?	____	____	________________
4. utilize vegetated swales vs curb and gutter?.............	____	____	________________
5. drain runoff to pervious areas?..................................	____	____	________________
6. utilize other measures or features?	____	____	________________

Worksheet for Conceptual Stormwater Management Site Plan (Continued)

Comments

2. Review of **Stormwater Management Design Approach**

   A. How will the *Stormwater Management* Design Approach be addressed for **Water Quality Protection?.......................** ___________________________________

   B. How will the Stormwater Design Approach be addressed for **Streambank Protection? ....** ___________________________________

   C. How will the Stormwater Design Approach be addressed for **On-Site Flood Control? ....** ___________________________________

   D. How will the Stormwater Design Approach be addressed for **Downstream Flood Control? ....** ___________________________________

3. Review of **Water Quality Volume Reduction Methods**

Can the Water Quality Volume be reduced by:

	Yes	No	Comments
A. conservation and/or restoration of natural areas?......	____	____	________________
B. use of **stream buffers? ....**	____	____	________________
C. use of **vegetated channels?..**	____	____	________________
D. use of **overland flow filtration/groundwater recharge?**	____	____	________________
E. use of **low imperviousness development? ....**	____	____	________________

4. Review of potential **hot spots**

   Are any of the following located or to be located on the site which may require special treatment and design consideration?

	Yes	No	Comments
A. Gas/fueling stations?**..**	____	____	________________
B. Vehicle maintenance areas?**..**	____	____	________________
C. Vehicle washing/steam cleaning areas?**..........................**	____	____	________________
D. Auto recycling facilities?**..**	____	____	________________
E. Illegal dumpsites? **...**	____	____	________________
F. Outdoor material storage areas? **.....................................**	____	____	________________
G. Loading and transfer areas? **..**	____	____	________________
H. Landfills? **...**	____	____	________________
I. Industrial facilities?**...**	____	____	________________
J. Other areas that may be a potential pollution source? **.....**	____	____	________________

Worksheet for Conceptual Stormwater Management Site Plan (Continued)

5. Review of **Storm Water Controls**	Included? Yes	No	Comments
Which of the following controls will potentially be used on the site?			
A. Alum Treatment System?...	____	____	________________
B. Bioretention System?..	____	____	________________
C. Culverts?	____	____	________________
D. Dry Detention?	____	____	________________
E. Energy Dissipation?	____	____	________________
F. Enhanced Swales?	____	____	________________
G. Extended Dry Detention?..	____	____	________________
H. Filter Strips?	____	____	________________
I. Grass Channels?	____	____	________________
J. Gravity (Oil-Grit) Separator?	____	____	________________
K. Infiltration Trenches?...	____	____	________________
L. Modular Porous Paver Systems?	____	____	________________
M. Multi-Purpose Detention Areas?	____	____	________________
N. Open Channels?	____	____	________________
O. Organic Filters?...	____	____	________________
P. Porous Concrete?	____	____	________________
Q. Proprietary Systems?..	____	____	________________
R. Sand Filters (Surface/Perimeter)?	____	____	________________
S. Storm Water Ponds?...	____	____	________________
T. Storm Water Wetlands?..	____	____	________________
U. Street Gutters/Inlets/Pipe Systems?	____	____	________________
V. Submerged Gravel Wetland?......................................	____	____	________________
W. Underground Detention?..	____	____	________________
X. Underground Sand Filters?..	____	____	________________
Y. Other controls?..	____	____	________________

Checklist for Conceptual Stormwater Management Site Plan Preparation and Review

	Included? Yes	No	Comments
Mapping and plans which illustrate at a minimum: (recommended scale of 1" = 50' or greater)			
1. Project Description			
A. Name, legal address, & telephone number of applicant .	____	____	________________
B. Name, legal address & telephone number of preparer....	____	____	________________
C. Common address and legal description of site...............	____	____	________________
D. Vicinity map	____	____	________________
E. Proposed land use with Standard Industrial Code No. ...	____	____	________________

	Yes	No	Comments
2. Existing Conditions			
A. Copy of applicable digital orthophoto showing proposed project boundaries..	____	____	________________
B. Existing and proposed topography (no greater than 2-foot contours recommended)	____	____	________________
C. Total Site Area and Total Impervious Area (acres)..........	____	____	________________
D. Benchmarks used for site control....................................	____	____	________________
E. Perennial and intermittent streams	____	____	________________
F. Predominant soils from USDA soil surveys and/or on site soil borings	____	____	________________
G. Boundaries of existing predominant vegetation.............	____	____	________________
H. Location and boundaries of natural feature protection and conservation areas such as wetlands, lakes, ponds, and other setbacks (e.g., stream buffers, drinking water well setbacks, septic setbacks, etc.)	____	____	________________
I. Location of existing roads, buildings, parking lots and other impervious areas	____	____	________________
J. Location of existing utilities (e.g., water, sewer, gas, electric) and easements..	____	____	________________
K. Location of existing conveyance systems such as storm drains, inlets, catch basins, channels, swales, and areas of overland flow	____	____	________________
L. Flow paths................	____	____	________________
M. Location of floodplain/floodway limits and relationship of site to upstream/downstream properties and drainages...	____	____	________________
N. Location and dimensions of existing channels, bridges or culvert crossings	____	____	________________

Checklist for Conceptual Stormwater Management Site Plan Preparation and Review (Continued)

	Yes	No	Comments
3. Conceptual Site Layout			
A. Complete the Conceptual Stormwater Management Plan Worksheet	____	____	__________________
B. Hydrologic analysis to determine conceptual runoff rates, volumes and velocities to support selection of Storm Water Controls..	____	____	__________________
C. Conceptual site design identifying site design practices used	____	____	__________________
D. Conceptual estimates of Stormwater Design Approach requirements..	____	____	__________________
E. Conceptual selection, location and size of proposed structural storm water controls.....................................	____	____	__________________
F. Conceptual limits of proposed clearing and grading. ..	____	____	__________________.

Checklist for Preliminary Stormwater Management Site Plan Preparation and Review

	Included?		
	Yes	**No**	**Comments**
Mapping and plans which illustrate at a minimum: (recommended scale of 1" = 50' or greater)			
1. Existing Conditions Hydrologic Analysis			
A. Existing and proposed topography (no greater than 2-foot contours recommended)	____	____	__________________
B. Total Site Area and Total Impervious Area (acres)..........	____	____	__________________
C. Benchmarks used for site control....................................	____	____	__________________
D. Perennial and intermittent streams	____	____	__________________
E. Predominant soils from USDA soil surveys or soil borings	____	____	__________________
F. Boundaries of existing predominant vegetation and proposed limits of clearing and grading	____	____	__________________
G. Location and boundaries of natural feature protection and conservation areas such as wetlands, lakes, ponds, and other setbacks (e.g., stream buffers, drinking water well setbacks, septic setbacks, etc.)	____	____	__________________
H. Location of existing and proposed roads, buildings, parking lots and other impervious areas.........................	____	____	__________________
I. Location of existing and proposed utilities (e.g., water, sewer, gas, electric) and easements	____	____	__________________
J. Preliminary selection and location of storm water controls	____	____	__________________
K. Location of existing and proposed conveyance systems such as storm drains, inlets, catch basins, channels, swales, and areas of overland flow................................	____	____	__________________
L. Flow paths...	____	____	__________________
M. Location of floodplain/floodway limits and relationship of site to upstream/downstream properties and drainages...	____	____	__________________
N. Preliminary location and dimensions of proposed channel modifications, such as bridge or culvert crossings	____	____	__________________
O. Existing conditions hydrologic analysis for runoff rates, volumes and velocities showing methodologies used and supporting calculations...	____	____	__________________

Checklist for Preliminary Stormwater Management Site Plan Preparation and Review (Continued)

	Included? Yes	No	Comments
2. Project Description and Design Considerations (updated information from Conceptual Plan)			
A. Name, legal address and telephone number of applicant			
B. Name, legal address and telephone number of preparer .	____	____	________________
C. Common address and legal description of site...............	____	____	________________
D. Vicinity map..	____	____	________________
E. Discussion of Stormwater Management Site Design Practices	____	____	________________
F. Discussion of Credits for Stormwater Management Site Design	____	____	________________
G. Discussion of storm water controls	____	____	________________
H. Discussion of groundwater recharge considerations	____	____	________________
I. Discussion of hotspot land uses and runoff treatment....	____	____	________________

	Yes	No	Comments
3. Post-Development Hydrologic Analysis			
A. Proposed (post-development) conditions hydrologic analysis for runoff rates, volumes, and velocities showing the methodologies used and supporting calculations	____	____	________________
B. Preliminary estimates of Stormwater Design Approach requirements	____	____	________________
C. Location and boundary of proposed natural feature protection areas	____	____	________________

	Yes	No	Comments
4. Downstream Assessments			
A. Preliminary analysis of potential downstream impact/effects of project, where necessary...................	____	____	________________

	Yes	No	Comments
5. Storm Water Management System Design			
A. Hydrologic and hydraulic analysis of the storm water management system for all applicable design storms ...	____	____	________________
B. Preliminary sizing calculations for storm water controls including contributing drainage area, storage, and outlet configuration...	____	____	________________
C. Narrative describing the selected storm water controls .	____	____	________________

Checklist for Final Stormwater Management Site Plan Preparation and Review

	Included? Yes	No	Comments
1. Existing Conditions Hydrologic Analysis			
A. Updated checklist from **Preliminary Stormwater Management Site Plan**…………………………………....	____	____	__________________
2. Project Description and Design Considerations			
A. Updated checklist from **Preliminary Stormwater Management Site Plan**…………………………………...	____	____	__________________
3. Post-Development Hydrologic Analysis			
A. Updated checklist from **Preliminary Stormwater Management Site Plan**………………………………..	____	____	__________________
B. Final sizing calculations for storm water controls including contributing drainage area, storage, and outlet configuration**...**	____	____	__________________
C. Stage-discharge or outlet rating curves and inflow and outflow hydrographs for storage facilities**.......................**	____	____	__________________
D. Final analysis of potential downstream impact/effects of project, where necessary **...**	____	____	__________________
E. Dam safety and breach analysis, where necessary **.......**	____	____	__________________
4. Downstream Assessments			
A. Update checklist from **Preliminary Stormwater Management Site Plan**…………………………………....	____	____	__________________

	Yes	No	Comments
5. Storm Water Management System Design			
A. Update checklist from **Preliminary Stormwater Management Site Plan**………………………………........	____	____	__________________
B. Existing and proposed structural elevations (e.g., invert of pipes, manholes, etc.)**...**	____	____	__________________
C. Design water surface elevations **.................................**	____	____	__________________
D. Structural details and specifications of structural control designs, outlet structures, embankments, spillways, grade control structures, conveyance channels, etc**.....**	____	____	__________________
E. Professional Engineer seal, signature and date **..............**	____	____	__________________
6. Construction Storm Water Pollution Prevention Plan			
A. Required elements specified in Design Manual for Construction and/or local ordinances**............................**	____	____	__________________
B. Sequence/phasing of construction and temporary stabilization measures**..**	____	____	__________________
A. Temporary structures that will be converted into permanent storm water controls **.................................**	____	____	__________________

Checklist for Final Stormwater Management Site Plan (Continued)

	Included? Yes	No	Comments
7. Landscaping Plan			
A. Arrangement of planted areas, natural areas, and other landscaped features..	____	____	__________________
B. Information required to construct landscaping elements ..	____	____	__________________
C. Descriptions and standards for the methods, materials and vegetation that are to be used	____	____	__________________

	Yes	No	Comments
8. Operations and Maintenance Plan			
A. Name, legal address and phone number of responsible parties for maintenance activities..................................	____	____	__________________
B. Description and schedule of maintenance tasks	____	____	__________________
C. Description of applicable easements	____	____	__________________
D. Description of funding source	____	____	__________________
E. Access and safety issues...	____	____	__________________
F. Procedures for testing and disposal of sediments, if required	____	____	__________________
G. Expected service life of structures and estimated cost to replace	____	____	__________________
H. Executed Maintenance Agreement(s), as required	____	____	__________________

	Yes	No	Comments
9. Evidence of Acquisition of Applicable Federal, State, and Local Permits			
A. USACE Regulatory Program permits...............................	____	____	__________________
B. 401 water quality certification...	____	____	__________________
C. Construction TPDES Construction permit......................	____	____	__________________
D. Other ______________________________	____	____	__________________
E. Other______________________________......................	____	____	__________________

	Yes	No	Comments
10. Waiver requests			
A. Evidence of acquisition of all necessary legal agreements (e.g., easements, covenants, land trusts, etc.)	____	____	__________________

Operation and Maintenance Inspection Report for Storm Water Management Ponds

Inspector Name	Project Location
Inspection Date	
Storm Water Pond	
Normal Pool	
Normally Dry	Watershed

Inspection Items	Checked? Yes / No	Maintenance Needed? Yes / No	Inspection Frequency	Comments
Pond Components				
1) Embankment and Emergency Spillway			A	
a) Adequate Vegetation and ground cover			A	
b) Embankment Erosion			A	
c) Animal Burrows			A	
d) Unauthorized plantings			A	
e) Crackling, bulging, or sliding of dam				
i) Upstream face			A	
ii) Downstream Face			A	
iii) Emergency Spillway			A	
f) Pond, toe, and chimney drains clear and functioning			A	
g) Leaks on downstream face			A	
h) Abutment protection or riprap failures			A	
i) Visual settlement or horizontal misalignment of top of dam			A	
j) Emergency spillway clear of debris			A	
k) Other (specify)			A	
2) Riser and principal spillway				
Type: Reinforced concrete ______				
Corrugated Pipe _______-				
Masonry _______				
a) Low flow orifice obstructed			A	
b) Low flow trash rack				
i) Debris removal necessary			A	
ii) Corrosion control			A	
c) Weir trash rack				
i) Debris removal necessary			A	
ii) Corrosion Control			A	

Inspection Items	Checked? Yes / No	Maintenance Needed? Yes / No	Inspection Frequency	Comments
d) Excessive sediment accumulation inside riser			A	
e) Concrete/Masonry condition Riser and barrels				
i) Cracks or displacement			A	
ii) Minor spalling (<1")			A	
iii) Major spalling (rebars exposed)			A	
iv) Joint failures			A	
v) Water tightness			A	
f) Metal Pipe condition			A	
g) Control Valve				
i) Operational/excercised			A	
ii) Chained and locked			A	
h) Pond drain valve				
i) Operational / exercised			A	
ii) Chained and locked			A	
i) Outfall channels flowing			A	
j) Other (specify)			A	
3) Permanent pool (wet ponds)				
a) Undesirable vegetative growth			M	
b) Floating or floatable debris removal required			M	
c) Visible pollution			M	
d) High water marks			M	
e) Shoreline problems			M	
f) Other (verify)			M	
4) Sediment forebays				
a) Sedimentation Noted			M	
b) Sediment removal when depth <50% design depth			M	
5) Dry pond areas				
a) Vegetation adequate			M	
b) Undesirable vegetative growth			M	
c) Undesirable woody vegetation			M	
d) Low flow channels clear of obstructions			M	
e) Standing water or wet spots			M	
f) Sediment and/or trash accumulation			M	
g) Other (specify)			M	
6) Condition of outfalls into ponds				
a) Riprap failures			A, S	
b) Slope erosion			A, S	
c) Storm drain pipes			A, S	
d) Endwalls / headwalls			A, S	
e) Other (specify)			A, S	
7) Other				

Inspection Items	Checked? Yes / No	Maintenance Needed? Yes / No	Inspection Frequency	Comments
a) Encroachments on ponds or easement area			M	
b) Complaints from residents (describe on back)			M	
c) Aesthetics				
i) Grass height			M	
ii) Graffiti removal necessary			M	
iii) Other (specify)			M	
d) Any public hazards (specify)			M	
e) Maintenance access			M	
8) Constructed wetland areas				
a) Vegetation healthy and growing			A	
b) Evidence of invasive species			A	
c) Excessive sedimentation in wetland area			A	

Inspection Frequency Key: A = Annual, M = Monthly, S = After major storm

Summary

1. Inspector Remarks: ____
____
____
____
____
____

2. Overall condition of Facility (check one)

___________ Acceptable

___________ Unacceptable

3. Dates any maintenance must be completed by:

____
____
____

____
Inspectors Signature

Operation and Maintenance Inspection Report for Filtration Facility

Inspector Name	Project Location
Inspection Date	
Watershed	
As-built Plans available?	

Inspection Items	Checked? Yes / No	Maintenance Needed? Yes / No	Inspection Frequency	Comments
1) Debris Removal				
a) Adjacent area clear of debris			M	
b) Inlets and outlets clear of debris			M	
c) Filtration facility free of debris			M	
2) Vegetation				
a) Adjacent area stabilized			M	
b) Grass mowed			M	
c) Any evidence of erosion			M	
3) Oil and grease				
a) Any evidence of filter clogging			M	
4) Water retention where required				
a) Water holding chambers at normal pool			M	
b) No evidence of leakage			M	
5) Sediment deposition				
a) Filtration chamber clean of sediments			A	
b) Water chambers not more than ½ full of sediments			A	
6) Structural components				
a) Any evidence of structural deterioration			A	
b) Grates in good condition			A	
c) Any evidence of spalling or cracking of structural parts			A	
7) Outlets / overflow spillway				
a) Good condition (no need of repair)			A	
b) Any evidence of erosion			A	
8) Overall function of facility				
a) Any evidence of flow bypassing facility			A	
b) Any noticeable odors outside of facility			A	

Inspection Items	Checked? Yes / No	Maintenance Needed? Yes / No	Inspection Frequency	Comments
9) Pump (where applicable)				
a) Catalog cuts and wiring diagram for pump available			A	
b) Waterproof conduits for wiring appear to be exact			A	
c) Panel box is well marked			A	
d) Any evidence of pump failure (excess water in pump well, etc.)			A	

Inspection Frequency Key: A = Annual, M = Monthly, S = After major storm

Necessary Action

If any of the items above where answered Yes for “Maintenance Needed”, a time frame needs to be established for repair or correction.

No action necessary. Continue Routine inspections.

Correct noted facility deficiencies by (date) ________________________

Facility repairs were previously indicated and completed. Site reinspection is necessary to verify corrections or improvements.

Site reinspection completed on (date) ________________________

Site reinpsection was satisfactory.
Next routine inspection is scheduled for approximately (date): ________________________

____
Inspectors Signature

Operation and Maintenance Inspection Report for Infiltration Trenches

Inspector Name	Project Location
Inspection Date	
Watershed	
As-built Plans available?	

Inspection Items	Checked? Yes / No	Maintenance Needed? Yes / No	Inspection Frequency	Comments
1) Debris Removal				
a) Trench surface clear of debris			M	
b) Inlets clear of debris			M	
c) Inflow pipes clear of debris			M	
d) Overflow spillway clear of debris			M	
2) Sediment traps, forebays, or pretreatment swales				
a) Obviously trapping sediment			A	
b) Greater than 50% of the original storage volume remaining			A	
3) Vegetation				
a) Mowing done when necessary			M	
b) Fertilized per specification			M	
c) Any evidence of erosion			M	
d) Contributing drainage area stabilized			M	
4) Dewatering				
a) Trench dewaters between storms			A	
5) Sediment removal of trench			A	
a) Any evidence of sedimentation in trench			A	
b) Does sediment accumulation currently require removal			A	
6) Inlets				
a) Good condition			A	
b) Any evidence of erosion			A	
7) Outlets / overflow spillway				
a) Good condition (no need of repair)			A	
b) Any evidence of erosion			A	
8) Aggregate repairs				
a) Surface of aggregate clean			A	

Inspection Items	Checked? Yes / No	Maintenance Needed? Yes / No	Inspection Frequency	Comments
b) Top layer of stone in need of replacement			A	
c) Trench in need of rehabilitation			A	
9) Vegetated surface				
a) Evidence of erosion present			M	
b) Perforated inlet functioning adequately			M	
c) Does water stand on vegetated surface			M	
d) Does good vegetative cover exist			M	
10) Overall function of facility				
a) Any evidence of flow bypassing facility			S	

Inspection Frequency Key: A = Annual, M = Monthly, S = After major storm

Necessary Action

If any of the items above where answered Yes for “Maintenance Needed”, a time frame needs to be established for repair or correction.

No action necessary. Continue Routine inspections.

Correct noted facility deficiencies by (date) ____________________________

Facility repairs were previously indicated and completed. Site reinspection is necessary to verify corrections or improvements.

Site reinspection completed on (date) ____________________________

Site reinpsection was satisfactory.
Next routine inspection is scheduled for approximately (date): ____________________________

____
Inspectors Signature

Operation and Maintenance Inspection Report for Enhanced Swales / Grass Channels / Filter Strips

Inspector Name	Project Location
Inspection Date	
Watershed	
As-built Plans available?	

Inspection Items	Checked? Yes / No	Maintenance Needed? Yes / No	Inspection Frequency	Comments
1) Debris Removal				
a) Facility and adjacent area clear of debris			M	
b) Inlets and outlets clear of debris			M	
c) Any dumping of yard wastes into facility			M	
d) Has litter (branches, etc.) been removed			M	
2) Vegetation				
a) Adjacent area stabilized			M	
b) Grass mowed			M	
c) Plant height not less than design water depth			M	
d) Fertilized per specifications			M	
e) Any evidence of erosion			M	
f) Is plant composition according to approved plans			M	
g) Any unauthorized or inappropriate plantings			M	
h) Any dead or diseased plants			M	
i) Any evidence of plant stress from inadequate watering			M	
j) Any evidence of deficient stakes or wires			M	
3) Oil and Grease				
a) Any evidence of filter clogging			M	
4) Dewatering				
a) Facility dewaters between storms			M	
5) Check dams / energy dissipators / sumps				
a) Any evidence of sedimentation buildup			A, S	
b) Are sumps greater than 50% full of sediment			A, S	

Inspection Items	Checked? Yes / No	Maintenance Needed? Yes / No	Inspection Frequency	Comments
c) Any evidence of erosion at downstream toe of drop structures			A, S	
6) Sedimentation deposition				
a) Swale clean of sediments			A	
b) Sediments should not be > than 20% of swale design depth			A	
7) Outlets / overflow spillway				
a) Good condition (no need for repair)			A, S	
b) Any evidence of erosion			A, S	
c) Any evidence of blockages			A, S	
8) Integrity of facility				
a) Has facility been blocked or filled inappropriately			A	
9) Bioretention Planting soil				
a) Any evidence of planting soil erosion			A	
10) Organic Layer				
a) Mulch covers entire site (NO voids) and to specificed thickness			A	
b) Mulch is in good condition			A	

Inspection Frequency Key: A = Annual, M = Monthly, S = After major storm

Necessary Action

If any of the items above where answered Yes for “Maintenance Needed”, a time frame needs to be established for repair or correction.

No action necessary. Continue Routine inspections.

Correct noted facility deficiencies by (date) ________________________

Facility repairs were previously indicated and completed. Site reinspection is necessary to verify corrections or improvements.

Site reinspection completed on (date) ________________________

Site reinpsection was satisfactory.
Next routine inspection is scheduled for approximately (date): ________________________

____
Inspectors Signature