# 6.0 Satisfying the Stormwater Management and Site Planning and Design Criteria

## 6.1 Overview

Section 4.0 presented a comprehensive set of post-construction stormwater management and site planning and design criteria that can be applied to new development and redevelopment activities occurring within the Coastal Nonpoint Source Management Area and Area of Special Interest. Satisfying these criteria requires the successful *integration* of natural resource protection and stormwater management with the site planning and design process (Figure 6.1).

This *integration* can be accomplished through the use of an approach to the site planning and design process that: (1) identifies and protects valuable natural resources; (2) limits land disturbance and the creation of new impervious and disturbed pervious cover; and (3) reduces and manages post-construction stormwater runoff rates, volumes and pollutant loads. This approach involves the use of two distinct, but complementary groups of natural resource protection and stormwater management techniques:

- Green Infrastructure Practices: Natural resource protection and stormwater management practices and techniques (i.e., better site planning and design techniques, low impact development practices) that can be used to help *prevent* increases in post-construction stormwater runoff rates, volumes and pollutant loads.

- Stormwater Management Practices: Stormwater management practices (e.g., wet ponds, swales) that can be used to *manage* post-construction stormwater runoff rates, volumes and pollutant loads.

The use of these natural resource protection and stormwater management techniques helps control and minimize the negative impacts of the land development process while retaining and, perhaps, even enhancing a developer's vision for a development site. When applied during the site planning and design process, they can be used to create more natural and aesthetically pleasing development projects and create more cost-effective post-construction stormwater management systems (ARC, 2001). The use of these techniques, particularly the green infrastructure practices, can even reduce overall development costs while maintaining or increasing the resale value of a development project (MacMullan and Reich, 2007, US EPA, 2007, Winer-Skonovd et al., 2006).

This Section of the Coastal Stormwater Supplement (CSS) provides information about using these natural resource protection and stormwater management techniques during the site planning and design process (Figure 6.1). In doing so, it provides guidance on an integrated, green infrastructure-based

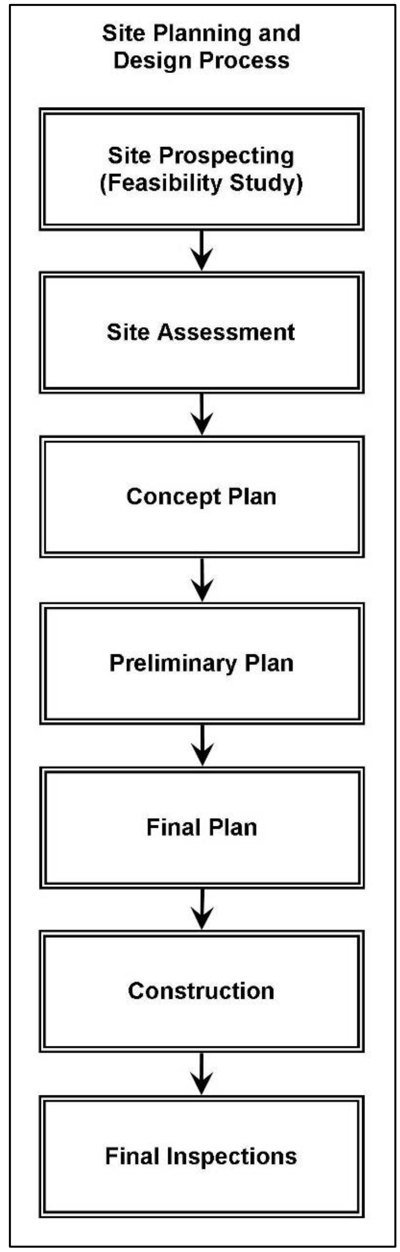


**Figure 6.1: Site Planning and Design Process**
(Source: Center for Watershed Protection)

approach to natural resource protection, stormwater management and site design that can be used to satisfy the stormwater management and site planning and design criteria presented in this CSS.

## 6.2 Site Planning and Design Process

Figure 6.1 depicts the site planning and design process that is typically used throughout coastal Georgia. Each phase of this process is briefly described below:

- Site Prospecting: During the site prospecting phase, some basic information is used to evaluate the feasibility of completing a development or redevelopment project. A *feasibility study* is typically used to evaluate the many factors that influence a developer's decision about whether or not to move forward with a potential development project. Factors that are typically evaluated during a *feasibility study* include information about site characteristics and constraints, applicable local, state and federal stormwater management and site planning and design requirements, adjacent land uses and access to local infrastructure (e.g., water, sanitary sewer).

- Site Assessment: Once a potential development or redevelopment project has been deemed feasible, a more thorough assessment of the development site is completed. The site assessment, which is typically completed using acceptable site reconnaissance and surveying techniques, provides additional information about a development site's characteristics and constraints. Once the assessment is complete, a developer can identify and analyze the natural, man-made, economic and social aspects of a potential development project, define the actual buildable area available on the development site and begin making some preliminary decisions about the layout of the proposed development project.

- Concept Plan: The results of the site assessment are typically used to create a concept plan (also known as a *sketch plan*) for the proposed development project. A concept plan is used to illustrate the basic layout of the proposed development project, including lots and roadways, and is usually reviewed with the local development review authority before additional resources are used to create a more detailed plan of development. During this phase, several alternative concept plans can be created and compared with one another to craft a plan of development that best "fits" the character of the development site (Figures 6.2-6.4).

- Preliminary Plan: A preliminary plan presents a more detailed layout of a proposed development project. It typically includes information about lots, buildings, roadways, parking areas, sidewalks, conservation areas, utilities and other infrastructure, including the post-construction stormwater management system. After the preliminary plan has been reviewed and approved by the local development review authority, a final plan may be prepared. There may be several iterations of the preliminary plan between the time that it is submitted and the time that it is approved by the local development review authority.

- Final Plan: The final plan adds further detail to the preliminary plan and reflects any changes to the plan of development that were requested or required by the local development review authority. The final plan typically includes all of the information that was included in the preliminary plan, as well as information about landscaping, pollution prevention, erosion and sediment control and long-term operation and maintenance of the site's post-construction stormwater management system. There may be several

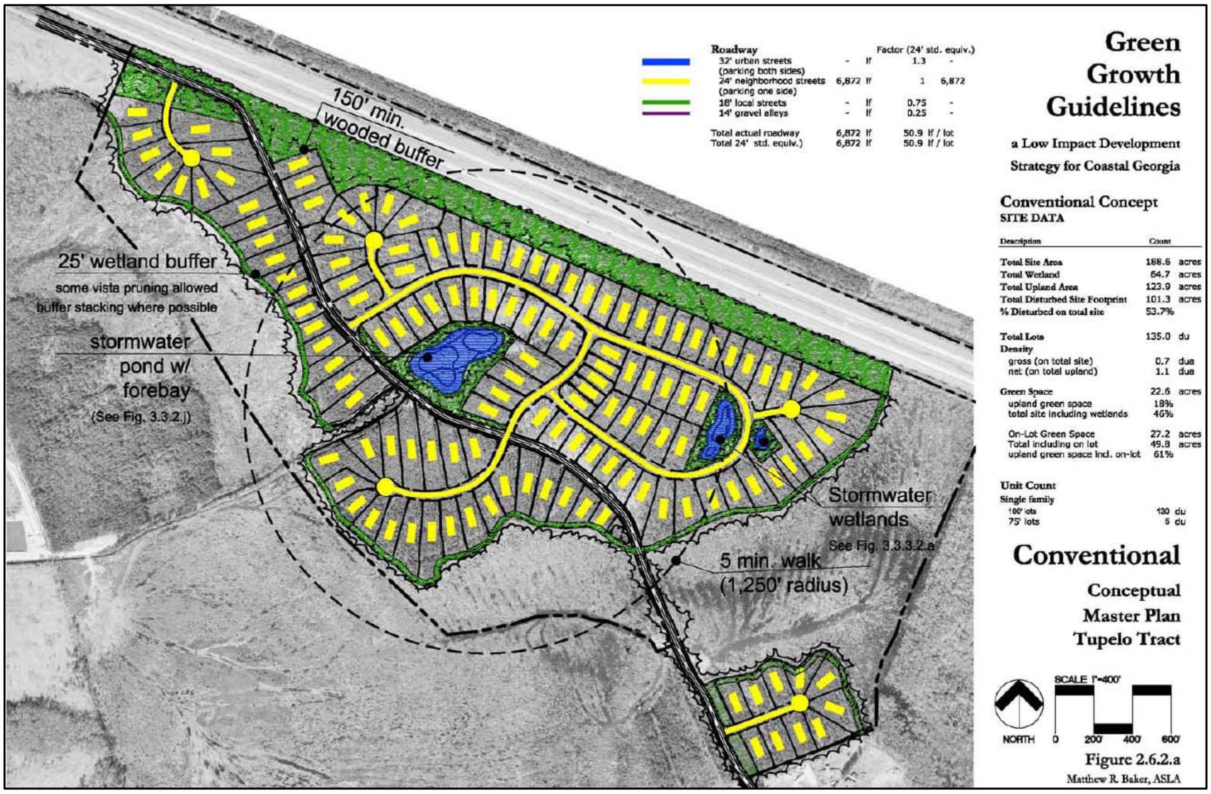


**Figure 6.2: Conventional Site Design**
(Source: Merrill et al., 2006)

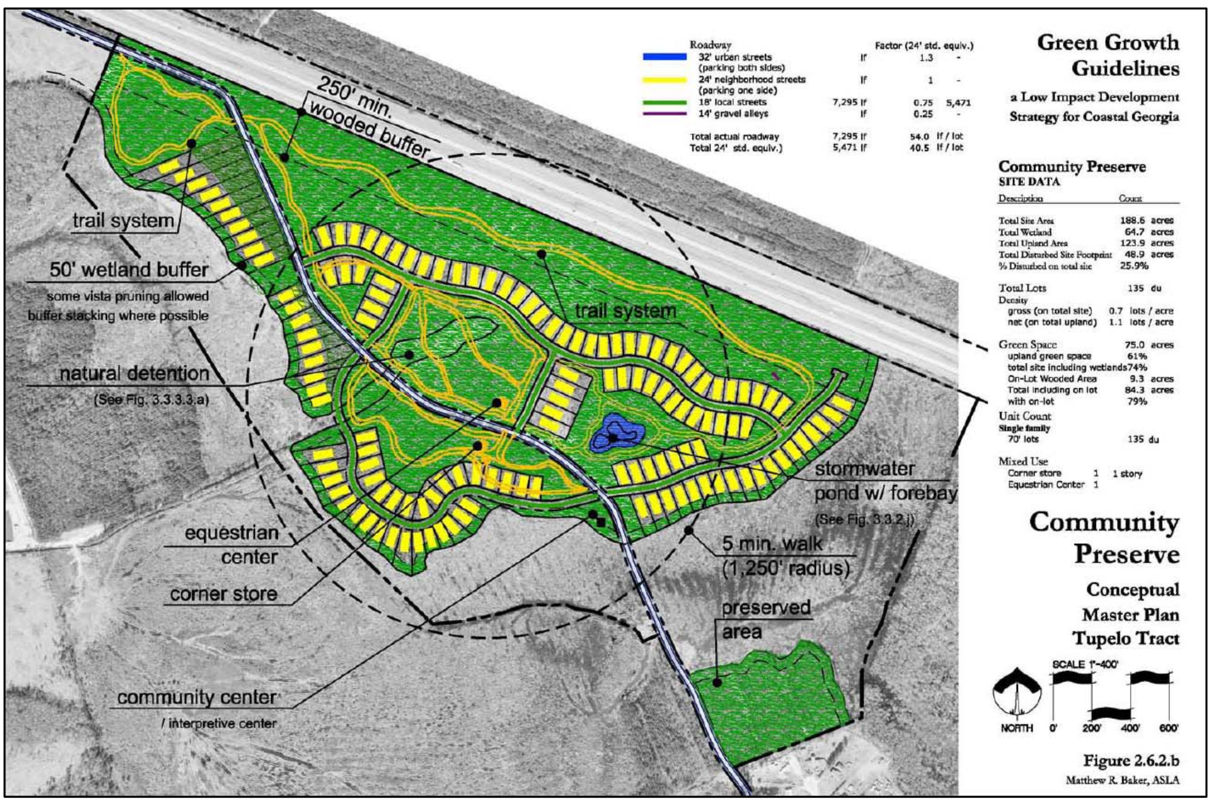


**Figure 6.3: Conservation Site Design**
(Source: Merrill et al., 2006)

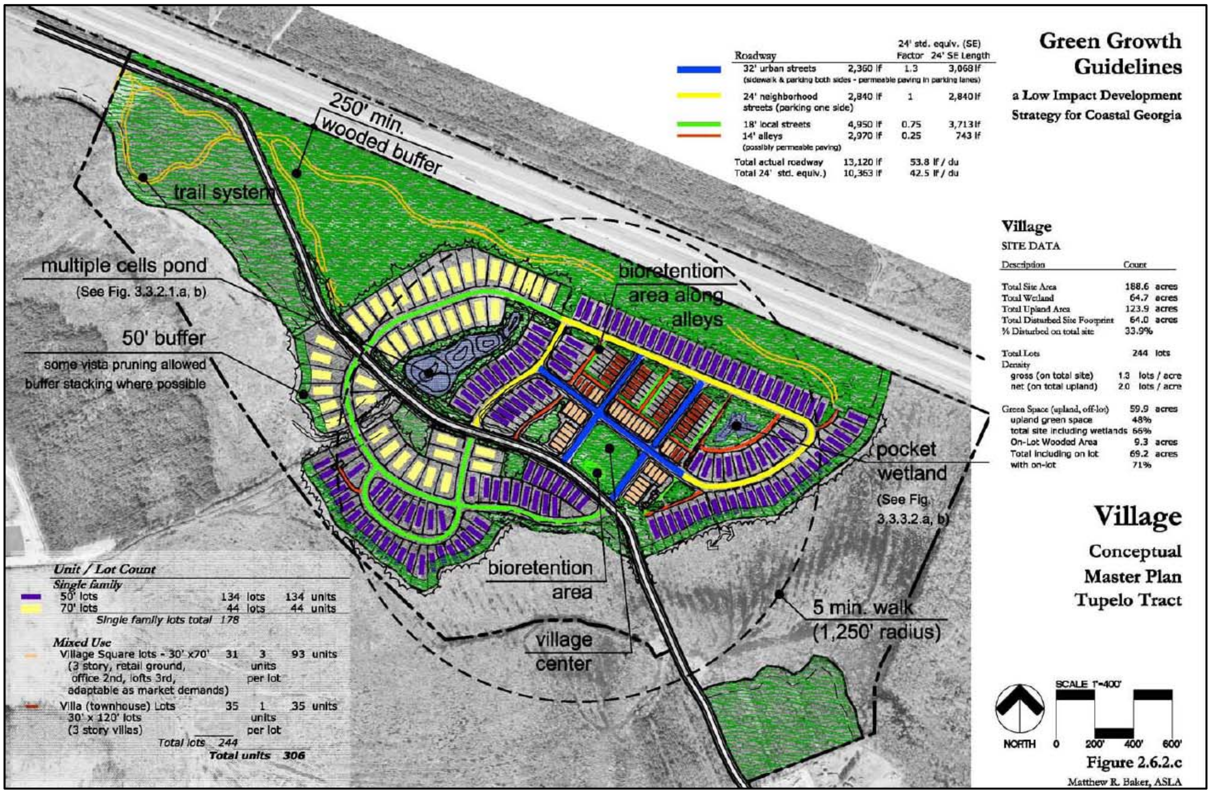


**Figure 6.4: New Urbanist Site Design**
(Source: Merrill et al., 2006)

iterations of the final plan between the time that it is submitted and the time that it is approved by the local development review authority.

- <u>Construction</u>: Once the final plan has been reviewed and approved, performance bonds are set and placed, contractors are retained and construction begins. During the construction phase, a development project may be inspected on a regular basis by the local development review authority to ensure that all roadways, parking areas, buildings, utilities and other infrastructure, including the post-construction stormwater management system, are being built in accordance with the approved final plan and that all primary and secondary conservation areas have been protected from any land disturbing activities.

- <u>Final Inspections</u>*:* Once construction is complete, final inspections take place to ensure that all roadways, parking areas, buildings, utilities and other infrastructure, including the post-construction stormwater management system, were built according to the approved final plan. As-built plans are also typically prepared and executed during this phase. If a development project passes all final inspections, an occupancy permit may be issued for the project.

### 6.3 Integrating Natural Resource Protection and Stormwater Management with the Site Planning and Design Process

In order to successfully *integrate* natural resource protection and stormwater management with the site planning and design process, site planning and design teams are encouraged to consider following questions at the beginning of the process:

- What valuable natural resources, both terrestrial and aquatic, can be found on the development site?

- How can better site planning techniques be used to protect these valuable natural resources from the direct impacts of the land development process?

- How can better site design techniques be used to minimize land disturbance and the creation of new impervious and disturbed pervious cover?

- What low impact development practices can be used to help preserve pre-development site hydrology and *reduce* post-construction stormwater runoff rates, volumes and pollutant loads?

- What stormwater management practices can be used to *manage* post-construction stormwater runoff rates, volumes and pollutant loads?

- Are there any site characteristics or constraints that prevent the use of any particular low impact development or stormwater management practices on the development site?

Although answering these questions is no easy task (i.e., answering these questions typically requires a solid understanding a development site's characteristics and constraints), answers to all of these questions can be readily obtained within the context of the six-step *stormwater management planning and design process* outlined below:

- Step 1: Pre-Application Meeting
- Step 2: Review of Local, State and Federal Stormwater Management and Site Planning and Design Requirements
- Step 3: Natural Resources Inventory
- Step 4: Prepare Stormwater Management Concept Plan
    - Step 4.1: Use Better Site Planning Techniques
    - Step 4.2: Use Better Site Design Techniques
    - Step 4.3: Calculate Stormwater Management Criteria
    - Step 4.4: Apply Low Impact Development Practices
    - Step 4.5: Check To See If Stormwater Management Criteria Have Been Met
    - Step 4.6: Apply Stormwater Management Practices
    - Step 4.7: Check To See If Stormwater Management Criteria Have Been Met
    - Step 4.8: Finalize Stormwater Management Concept Plan
- Step 5: Consultation Meeting
- Step 6: Prepare Stormwater Management Design Plan

Each step in this *stormwater management planning and design process* corresponds to a particular phase of the overall site planning and design process (Figure 6.5). Consequently, it can be used to *integrate* natural resource protection and stormwater management with the site planning and design process and to satisfy the stormwater management and site planning and design criteria presented in this CSS.

Each step in the *stormwater management planning and design process* is described in more detail below.

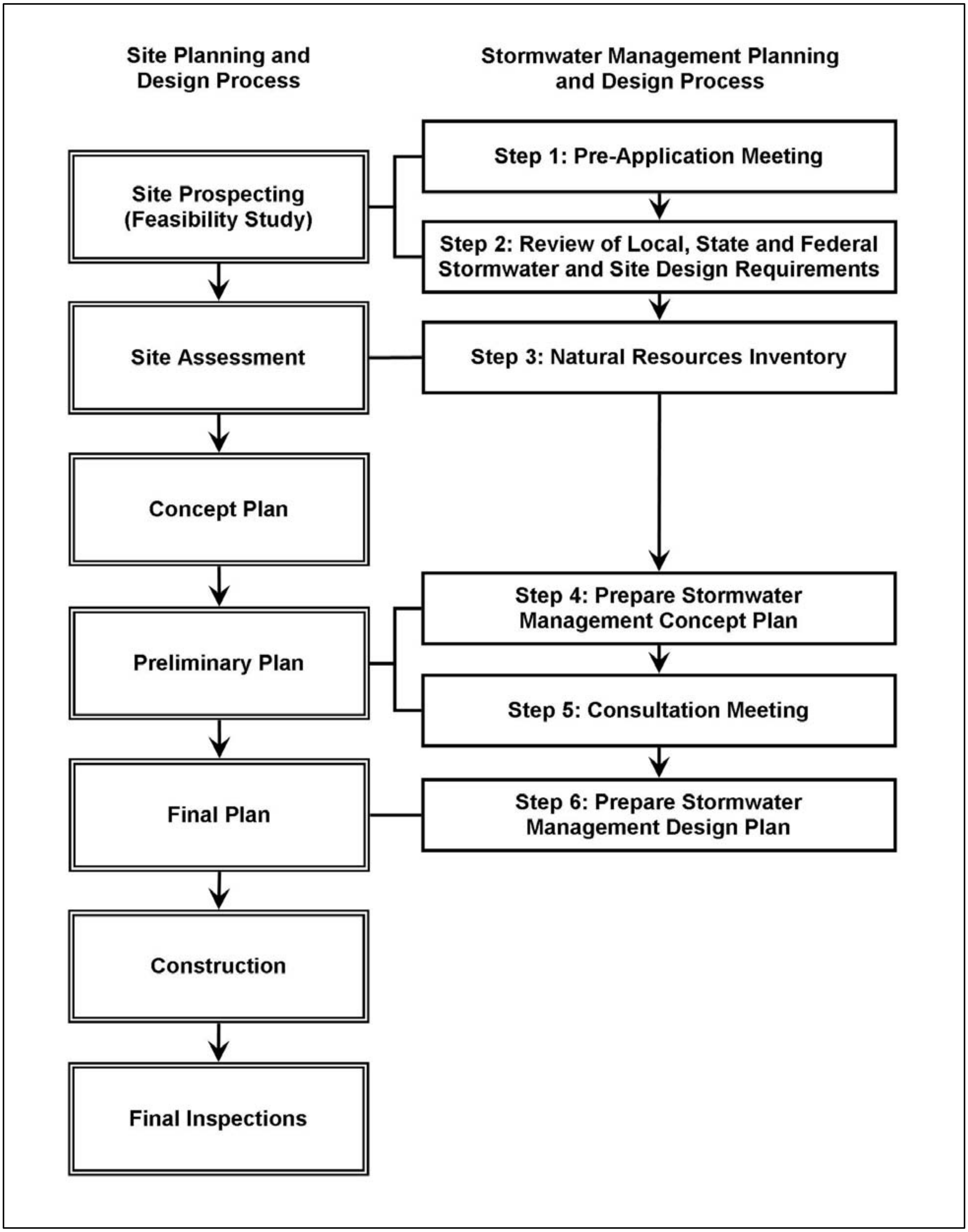


**Figure 6.5: Integrating Natural Resource Protection and Stormwater Management with the Site Planning and Design Process**
(Source: Center for Watershed Protection)

### 6.3.1 Step 1: Pre-Application Meeting

It is *recommended* that a pre-application meeting between the site planning and design team and the local development review authority occur at the very beginning of the *stormwater management planning and design process*. This meeting, which should occur during the site prospecting phase of the overall site planning and design process (Figure 6.5), helps establish a relationship between the site planning and design team and the local development review authority. The pre-application meeting also provides an opportunity to discuss the local stormwater management and site planning and design criteria that will apply to the proposed development project, which increases the likelihood that the remainder of the site planning and design process will proceed both quickly and smoothly. If representatives from the appropriate state and federal agencies are able to attend the meeting, it can also be used to discuss the state and federal regulations (e.g., Coastal Marshlands Protection Act, Georgia Erosion and Sediment Control Act, Clean Water Act, Endangered Species Act) that will apply to the development project.

If a joint site visit can be conducted as part of the meeting, the pre-application meeting can also be used to identify and discuss potential natural resource protection and stormwater management strategies. By walking the site together, the site planning and design team and representatives of the local development review authority can identify potential site constraints, delineate potential primary and secondary conservation areas and define general expectations for the rest of the site planning and design process.

### 6.3.2 Step 2: Review of Local, State and Federal Stormwater Management and Site Planning and Design Requirements

Once a pre-application meeting has been completed, it is *recommended* that the site planning and design team review the local, state and federal stormwater management and site planning and design requirements that will apply to the proposed development project. This review should occur during the site prospecting phase of the overall site planning and design process (Figure 6.5), while the *feasibility study* is still being completed.

The stormwater management and site planning and design requirements that apply to a particular development project may include the stormwater management and site planning and design criteria presented in this CSS, as well as the requirements spelled out in other local, state and federal regulations (e.g., local zoning ordinances, local subdivision ordinances, Coastal Marshlands Protection Act, Georgia Erosion and Sediment Control Act). Typically, information about the local stormwater management and site planning and design requirements that will apply to a particular development project can be obtained directly from a review of local codes and ordinances or from discussions with representatives of the local development review authority. These discussions can be held during the pre-application meeting (Section 6.3.1). Information about the state and federal requirements that apply to a proposed development project can be obtained from agency websites or from discussions with representatives of the appropriate state and federal agencies.

During their review of stormwater management and site planning and design requirements, site planning and design teams should also investigate opportunities and incentives for land conservation, such as those offered through the Georgia Land Conservation Program (i.e., tax incentives for donations of conserved lands or conservation easements), and opportunities and incentives for *conservation development* (Box 6.1).

**Box 6.1: Conservation Development**

Conservation development, also known as *open space development* or *cluster development*, is a site planning and design technique used to concentrate structures and impervious surfaces in a small portion of a development site, leaving room for larger conservation areas and managed open spaces elsewhere on the site (Figure 6.6). Smaller lot sizes and alternative lot designs (Section 7.7.9) are typically used to "cluster" structures and other impervious surfaces within these conservation developments.

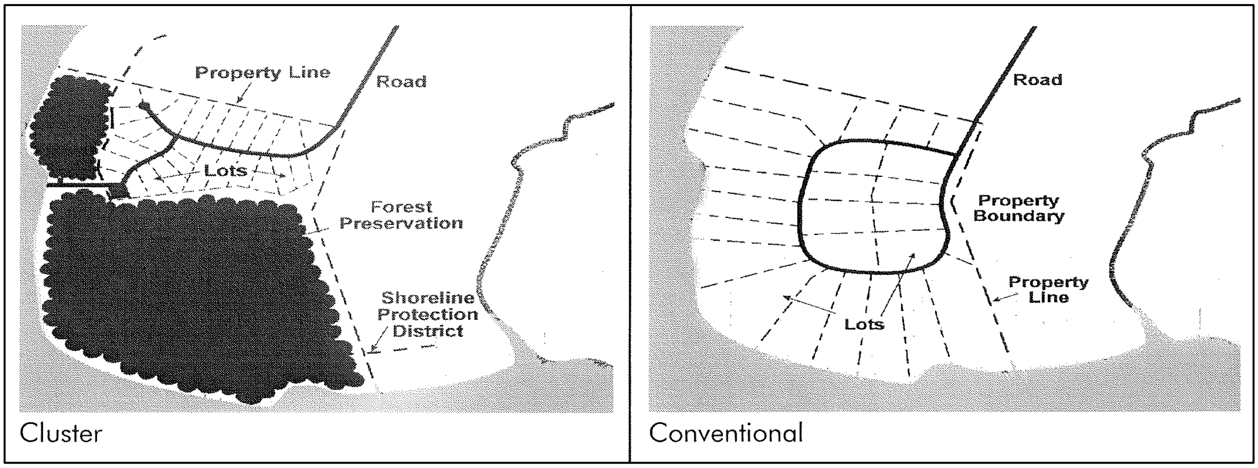


**Figure 6.6: Conservation (Cluster) Development Versus Conventional Development**
(Source: Center for Watershed Protection, 1998)

Conservation development projects provide a host of environmental benefits that are typically more difficult to achieve with conventional site design techniques. They provide for better natural resource protection on development sites and inherently limit increases in site imperviousness, sometimes by as much as 40 to 60 percent (CWP, 1998). Reduced site imperviousness results in reduced post-construction stormwater runoff rates, volumes and pollutant loads, which helps better protect both on-site and downstream aquatic resources from the negative impacts of the land development process. Reduced stormwater runoff rates, volumes and pollutant loads also help reduce the size of and need for storm drain systems and stormwater management practices on development sites.

As a number of recent studies have shown (MacMullan and Reich, 2007, US EPA, 2007, Winer-Skonovd et al., 2006), conservation development projects can also be significantly less expensive to build than more conventional development projects. Most of the cost savings can be attributed to the reduced amount of infrastructure (e.g., roads, sidewalks, post-construction stormwater management practices) needed on these development projects. And while these projects are frequently less expensive to build, developers often find that the lots located within conservation developments command higher prices and sell more quickly than those located within more conventional developments (ARC, 2001).

### 6.3.3 Step 3: Natural Resources Inventory

Once the potential development or redevelopment project has been deemed feasible, it is *recommended* that acceptable site reconnaissance and surveying techniques be used to complete a thorough assessment of the natural resources, both terrestrial and aquatic, found on the development site. The identification and subsequent preservation and/or restoration of these natural resources helps reduce the negative impacts of the land development process "by design." The natural resources inventory should be completed during the site assessment phase of the overall site planning and design process (Figure 6.5), in accordance with site planning and design criteria #1 (SP&D Criteria #1) (Section 4.3.1).

Once the natural resources inventory has been completed and a *site fingerprint* has been created, the site planning and design team should have a better understanding of a development site's characteristics and constraints. This information can be used to identify primary and secondary conservation areas and define the actual buildable area available on the development site (Figure 6.7). Along with information about adjacent land uses and available infrastructure (e.g., roads, utilities), the *site fingerprint* can also be used to make some preliminary decisions about the layout of the proposed development project and to guide the creation of the stormwater management concept plan (Section 6.3.4).

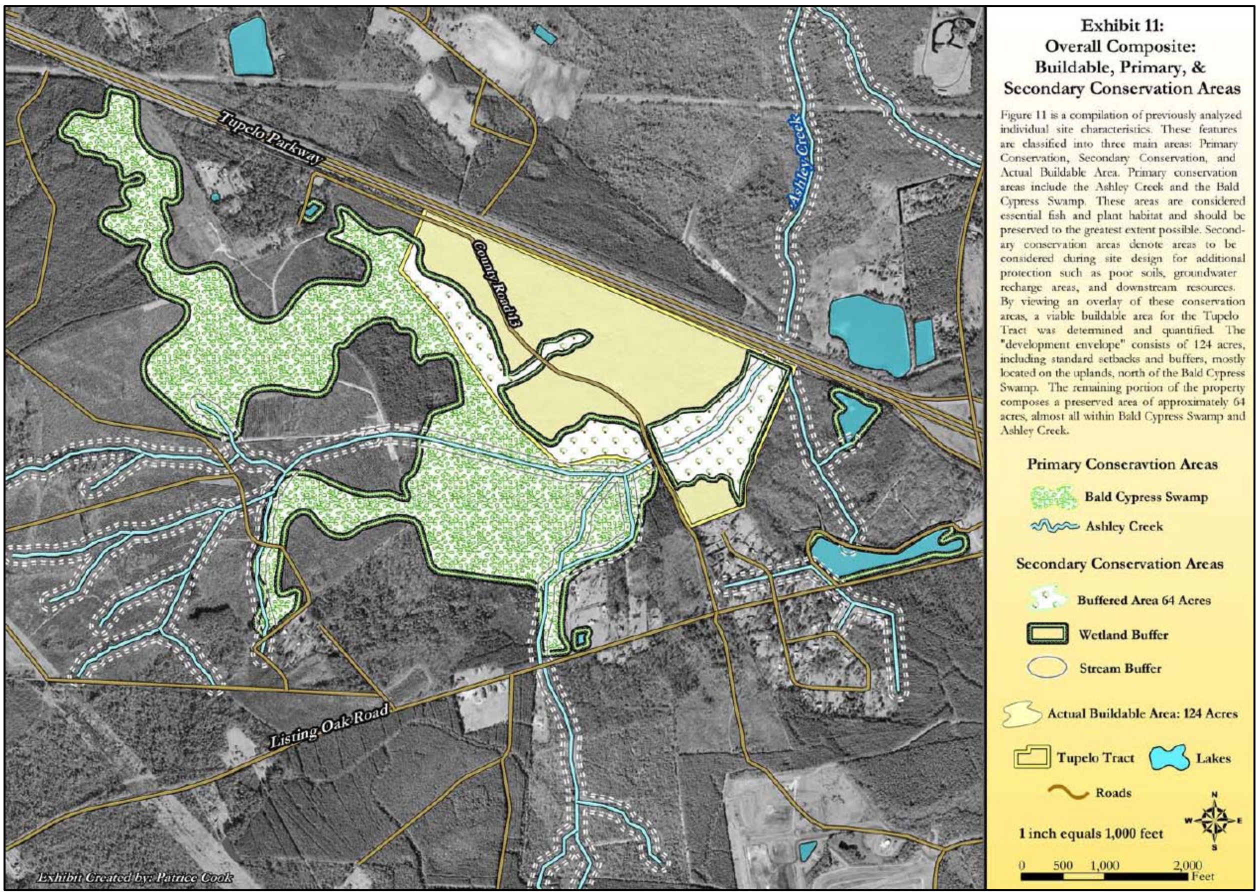


**Figure 6.7: Buildable Area and Primary and Secondary Conservation Areas**
(Source: Merrill et al., 2006)

Although a lot of the information needed to complete the natural resources inventory may need to be gathered through site reconnaissance and surveying, some of it may be available directly from the local development review authority, other state and federal agencies or from the internet. A comprehensive list of internet sites that act as clearinghouses for Geographic Information System (GIS) data and other spatial data, along with additional information about completing a site assessment and natural resources inventory, is provided in the *Green Growth Guidelines* (Merrill et al., 2006).

### 6.3.4 Step 4: Prepare Stormwater Management Concept Plan

After the natural resources inventory has been completed, it is *recommended* that the *site fingerprint* be used to develop a stormwater management concept plan for the proposed development project. In accordance with SP&D Criteria #3 (Section 4.3.3), the stormwater management concept plan should illustrate the layout of the proposed development project and should show, in general, how post-construction stormwater runoff will be managed on the development site.

The creation of a stormwater management concept plan allows the site planning and design team make to some preliminary decisions about the layout of the proposed development project. If it is submitted to the local development review authority prior to the preparation and submittal of the stormwater management design plan (Section 6.3.5), it can also be used to solicit early feedback on the project and on the green infrastructure and stormwater management practices that will be used to manage post-construction stormwater runoff on the development site.

During the creation of the stormwater management concept plan, most of the site layout, including the layout of lots, buildings, roadways, parking areas, sidewalks and green infrastructure and stormwater management practices, will be completed. Consequently, it is very important that natural resource protection and stormwater management be considered throughout this part of the *stormwater management planning and design process*. If they are not, it will be very difficult to meet the stormwater management and site planning and design criteria presented in this CSS.

To help ensure that natural resource protection and stormwater management are considered throughout this part of the *stormwater management planning and design process*, it is *recommended* that an iterative, eight-step process (Figure 6.8) be used to create a stormwater management concept plan:

- Step 4.1: Use Better Site Planning Techniques
- Step 4.2: Use Better Site Design Techniques
- Step 4.3: Calculate Stormwater Management Criteria
- Step 4.4: Apply Low Impact Development Practices
- Step 4.5: Check To See If Stormwater Management Criteria Have Been Met
- Step 4.6: Apply Stormwater Management Practices
- Step 4.7: Check To See If Stormwater Management Criteria Have Been Met
- Step 4.8: Finalize Stormwater Management Concept Plan

Each step in this iterative, eight-step process for creating a stormwater management concept plan is described in more detail below. It is important to note that this iterative site planning and design process can be completed in conjunction with the *Coastal Stormwater Supplement Site Planning and Design Worksheet*, which is available for free download from the following websites:

http://www.gaepd.org
http://www.mpcnaturalresources.org
http://www.coastalgeorgiardc.org.

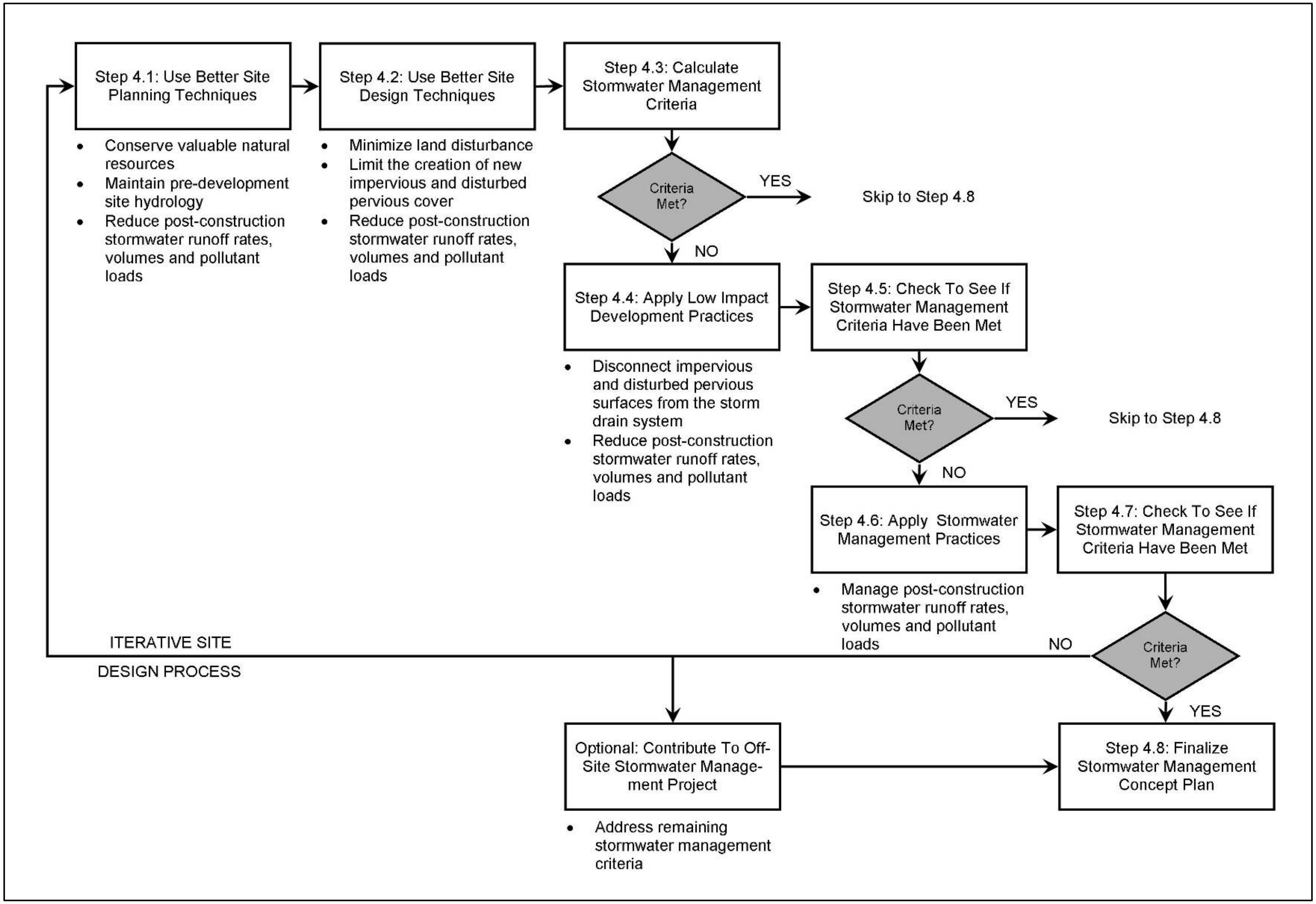


**Figure 6.8: Developing a Stormwater Management Concept Plan**
(Source: Center for Watershed Protection)

#### 6.3.4.1 Step 4.1: Use Better Site Planning Techniques

The first and, perhaps, most important step in the process of developing a stormwater management concept plan is to use better site planning techniques during the layout of the proposed development project. The better site planning techniques *recommended* for use in coastal Georgia include:

Better Site Planning Techniques

- Protect Primary Conservation Areas
- Protect Secondary Conservation Areas

The use of these better site planning techniques not only helps protect important primary and secondary conservation areas from the direct impacts of the land development process, but also helps preserve pre-development site hydrology and reduce post-construction stormwater runoff rates, volumes and pollutant loads. These better site planning techniques also provide a number of other environmental and economic benefits, including reduced land disturbance and soil erosion, improved air quality, increased carbon sequestration, improved aesthetics and improved human health (US EPA, 2008).

***Applying Better Site Planning Techniques During the Site Planning & Design Process***

After completing the natural resources inventory (Section 6.3.3), the site planning and design team should be able to identify the primary and secondary conservation areas found on the development site. In accordance with SP&D Criteria #2 (Section 4.3.2), it is *recommended* that:

(1) The following primary conservation areas, which provide habitat for high priority plant and animal species (Appendix A) and are considered to be high priority habitat areas (WRD, 2005), be protected from the direct impacts of the land development process:

- Aquatic Resources
    - Rivers
    - Perennial and Intermittent Streams
    - Freshwater Wetlands
    - Tidal Rivers and Streams
    - Tidal Creeks
    - Coastal Marshlands
    - Tidal Flats
    - Scrub-Shrub Wetlands
    - Near Coastal Waters
    - Beaches
- Terrestrial Resources
    - Dunes
    - Maritime Forests
    - Marsh Hammocks
    - Evergreen Hammocks
    - Canebrakes
    - Bottomland Hardwood Forests
    - Beech-Magnolia Forests
    - Pine Flatwoods
    - Longleaf Pine-Wiregrass Savannas
    - Longleaf Pine-Scrub Oak Woodlands

- Other Resources
  - o Aquatic Buffers
  - o Shellfish Harvesting Areas
  - o Other High Priority Habitat Areas

(2) Consideration be given to protecting the following secondary conservation areas from the direct impacts of the land development process:

- General Resources
  - o Natural Drainage Features (e.g., Swales, Basins, Depressional Areas)
  - o Erodible Soils
  - o Steep Slopes (i.e., Areas with Slopes Greater Than 15%)
  - o Trees and Other Existing Vegetation
- Aquatic Resources
  - o Groundwater Recharge Areas
  - o Wellhead Protection Areas
- Other Resources
  - o Floodplains

All primary and secondary conservation areas that will be protected from the direct impacts of the land development process should be clearly identified on the stormwater management concept plan (Figure 6.9). They should be maintained in an undisturbed, natural state before, during and after construction, and should be protected in perpetuity through a legally-enforceable conservation instrument (e.g., conservation easement, deed restriction). Additional information about how to apply these better site planning techniques on a development site can be found in Section 7.6.

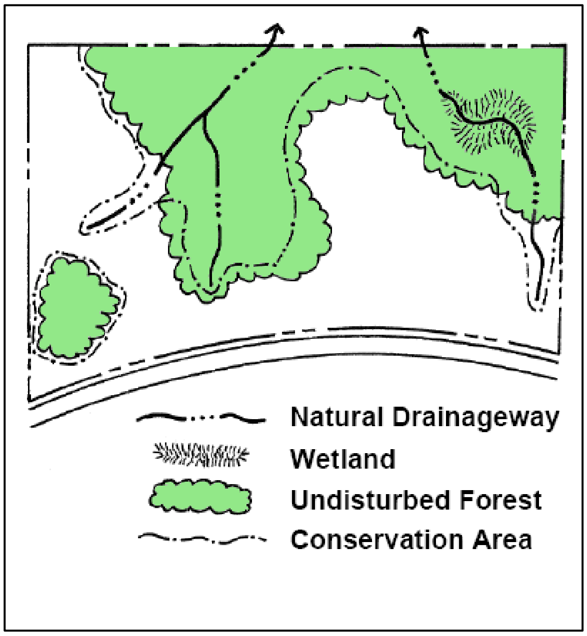


**Figure 6.9: Delineation of Primary and Secondary Conservation Areas**
(Source: Atlanta Regional Commission, 2001)

***Using Better Site Planning Techniques to Help Satisfy the Stormwater Management Criteria***

Although protecting primary and secondary conservation areas can be thought of as a "self-crediting" stormwater management technique (i.e., protecting them *implicitly* reduces post-construction stormwater runoff rates, volumes and pollutant loads), it is important not to overlook the stormwater management and other environmental benefits that these better site planning techniques provide. Consequently, they have been assigned quantifiable stormwater management "credits" that can be used when calculating the stormwater runoff volumes associated with the post-construction stormwater management criteria (SWM Criteria) presented in this CSS. While Table 6.1 summarizes these "credits," additional information about them, including information about how they can be used to help satisfy the SWM Criteria presented in this CSS, is provided in Section 7.6.

| Table 6.1: How Better Site Planning Techniques Can Be Used To Help Satisfy the Stormwater Management Criteria | | | | | |
|---|---|---|---|---|---|
| **Better Site Planning Technique** | **Stormwater Runoff Reduction** | **Water Quality Protection** | **Aquatic Resource Protection** | **Overbank Flood Protection** | **Extreme Flood Protection** |
| Protect Primary Conservation Areas<br><br>Protect Secondary Conservation Areas | **"Credit":**<br>Subtract any *primary and secondary conservation areas* from the total site area when calculating the runoff reduction volume ($RR_v$) that applies to a development site. | **"Credit":**<br>Subtract any *primary and secondary conservation areas* from the total site area when calculating the runoff reduction volume ($RR_v$) that applies to a development site. | **"Credit":**<br>Assume that the post-development hydrologic conditions of any *primary and secondary conservation areas* are equivalent to the pre-development hydrologic conditions for those same areas. | **"Credit":**<br>Assume that the post-development hydrologic conditions of any *primary and secondary conservation areas* are equivalent to the pre-development hydrologic conditions for those same areas. | **"Credit":**<br>Assume that the post-development hydrologic conditions of any *primary and secondary conservation areas* are equivalent to the pre-development hydrologic conditions for those same areas. |

#### 6.3.4.2 Step 4.2: Use Better Site Design Techniques

The next step in the process of developing a stormwater management concept plan is to use better site design techniques during the design of the proposed development project. The better site design techniques *recommended* for use in coastal Georgia include:

<u>Better Site Design Techniques</u>

- Reduce Clearing and Grading Limits
- Reduce Roadway Lengths and Widths
- Use Fewer or Alternative Cul-de-Sacs
- Reduce Parking Lot Footprints
- Create Landscaping Areas in Parking Lots
- Reduce Driveway Lengths and Widths
- Reduce Sidewalk Lengths and Widths
- Reduce Building Footprints
- Reduce Setbacks and Frontages

The use of these better site design techniques not only helps minimize land disturbance and the creation of new impervious and disturbed pervious cover, but also helps preserve pre-development site hydrology and reduce post-construction stormwater runoff rates, volumes and pollutant loads. These better site design techniques also provide a number of other environmental and economic benefits, including reduced land disturbance and soil erosion, urban heat island mitigation, improved aesthetics and improved human health (US EPA, 2008).

***Applying Better Site Design Techniques During the Site Planning & Design Process***

After completing the natural resources inventory (Section 6.3.3) and using better site planning techniques to protect primary and secondary conservation areas (Section 6.3.4.1), the site planning and design team should be able to define the buildable area on the development site. In accordance with SP&D Criteria #2 (Section 4.3.2), it is *recommended* that consideration be given to using better site design techniques to minimize land disturbance and limit the creation of new impervious and disturbed pervious cover within this buildable area. Additional information about these better site design techniques, including information about how to use them on a development site, can be found in Section 7.7.

It is important to note that, although all of the better site design techniques listed above are *recommended* for use in coastal Georgia, their use may be restricted by local codes and ordinances. Many communities across the country have found that their own local “development rules” (e.g., subdivision ordinances, zoning ordinances, parking lot and street design standards) have prevented these better site design techniques from being applied during the site planning and design process (CWP, 1998). These communities have found that their own codes and ordinances are responsible for the wide streets, expansive parking lots and large lot subdivisions that are crowding out the very natural resources they are trying to protect.

Obviously, it is difficult to make use of the *recommended* better site design techniques listed above when local “development rules” restrict their use. Although the Center for Watershed Protection (CWP, 1998) has developed a process that Georgia’s coastal communities can use to review and revise these “development rules,” it often takes some time to work through this process. Therefore, until these revisions have been completed and all of the barriers to the use of better site design techniques have been removed, site planning and design teams are encouraged to consult with the local development review authority to identify any local restrictions on the use of the better site design techniques discussed in this CSS.

***Using Better Site Design Techniques to Help Satisfy the Stormwater Management Criteria***

Although the use of better site design techniques can be thought of as a “self-crediting” stormwater management technique (i.e., using them *implicitly* reduces post-construction stormwater runoff rates, volumes and pollutant loads), it is important not to overlook the stormwater management and other environmental benefits that these techniques provide. Consequently, they have been assigned quantifiable stormwater management “credits” that can be used when calculating the stormwater runoff volumes associated with the SWM Criteria presented in this CSS. While Table 6.2 summarizes these “credits,” additional information about them, including information about how they can be used to help satisfy the SWM Criteria presented in this CSS, is provided in Section 7.7.

**Table 6.2: How Better Site Design Techniques Can Be Used to Help Satisfy the Stormwater Management Criteria**

| Better Site Design Technique | Stormwater Runoff Reduction | Water Quality Protection | Aquatic Resource Protection | Overbank Flood Protection | Extreme Flood Protection |
|---|---|---|---|---|---|
| Reduce Clearing and Grading Limits | **"Credit":** Subtract 50% of any *undisturbed pervious areas* from the total site area when calculating the runoff reduction volume ($RR_v$) that applies to a development site. | **"Credit":** Subtract 50% of any *undisturbed pervious areas* from the total site area when calculating the runoff reduction volume ($RR_v$) that applies to a development site. | **"Credit":** Assume that the post-development hydrologic conditions of any *undisturbed pervious areas* are equivalent to the pre-development hydrologic conditions for those same areas. | **"Credit":** Assume that the post-development hydrologic conditions of any *undisturbed pervious areas* are equivalent to the pre-development hydrologic conditions for those same areas. | **"Credit":** Assume that the post-development hydrologic conditions of any *undisturbed pervious areas* are equivalent to the pre-development hydrologic conditions for those same areas. |
| Reduce Roadway Lengths and Widths | **"Credit":** "Self-crediting," in that minimizing the creation of new impervious cover results in a lower volumetric runoff coefficient ($R_v$) and, consequently, a lower runoff reduction volume ($RR_v$) on a development site. | **"Credit":** "Self-crediting," in that minimizing the creation of new impervious cover results in a lower volumetric runoff coefficient ($R_v$) and, consequently, a lower runoff reduction volume ($RR_v$) on a development site. | **"Credit":** "Self-crediting," in that minimizing the creation of new impervious cover results in a lower runoff curve number (CN) and, consequently, a lower aquatic resource protection volume ($ARP_v$) on a development site. | **"Credit":** "Self-crediting," in that minimizing the creation of new impervious cover results in a lower runoff curve number (CN) and, consequently, a lower overbank peak discharge ($Q_{p25}$) on a development site. | **"Credit":** "Self-crediting," in that minimizing the creation of new impervious cover results in a lower runoff curve number (CN) and, consequently, a lower extreme peak discharge ($Q_{p100}$) on a development site. |
| Use Fewer or Alternative Cul-de-Sacs | | | | | |
| Reduce Parking Lot Footprints | | | | | |
| Create Landscaping Areas in Parking Lots | | | | | |
| Reduce Driveway Lengths and Widths | | | | | |
| Reduce Sidewalk Lengths and Widths | | | | | |
| Reduce Building Footprints | | | | | |
| Reduce Setbacks and Frontages | | | | | |

### 6.3.4.3 Step 4.3: Calculate Stormwater Management Criteria

By using a variety of better site planning and design techniques during the creation of a stormwater management concept plan (Figure 6.10), it is possible to significantly reduce post-construction stormwater runoff rates, volumes and pollutant loads on a development site. This helps reduce the size and cost of the low impact development and stormwater management practices that are needed to satisfy the SWM Criteria presented in this CSS, which typically results in significant cost savings for the developer and, when long-term maintenance costs are considered, for the local development review authority as well. Consequently, in accordance with SP&D Criteria #2, it is *recommended* that better site planning and design techniques be used to the *maximum extent practical* during the creation of a stormwater management concept plan.

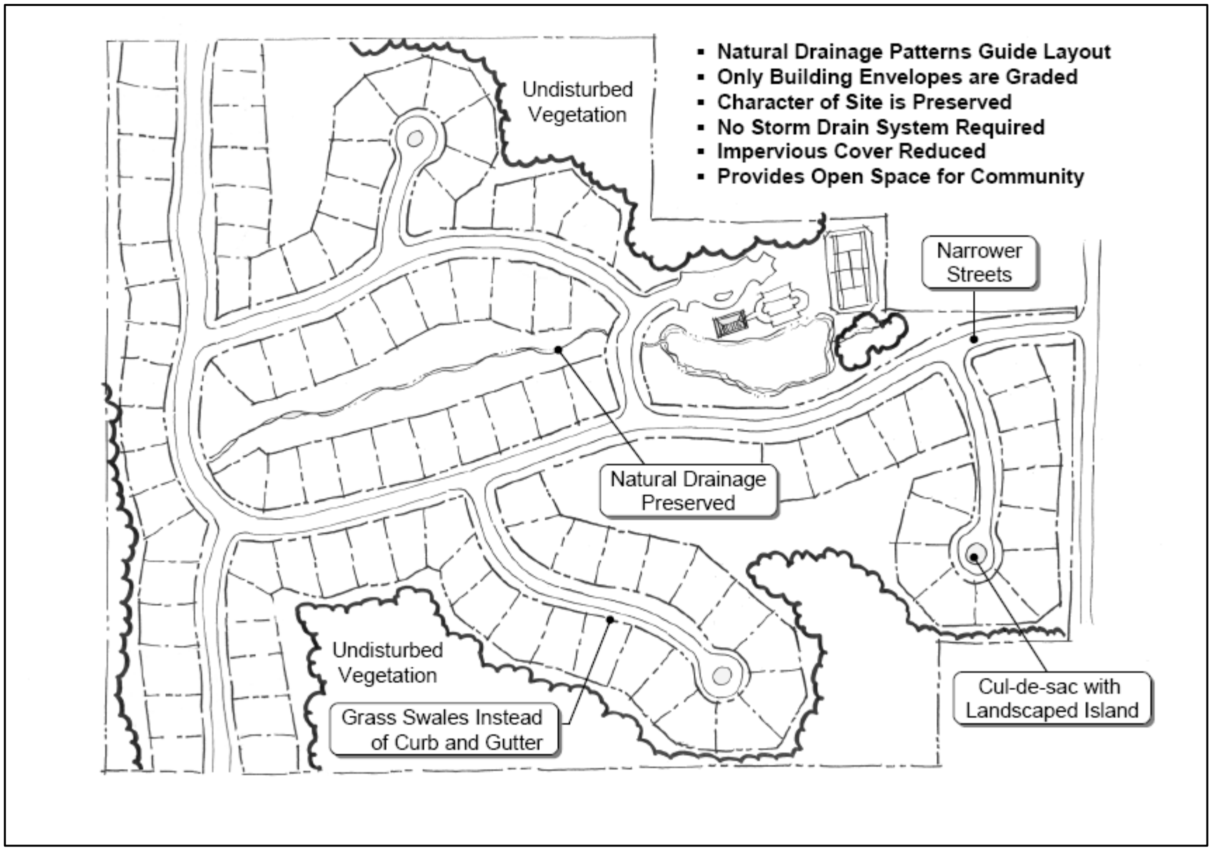


**Figure 6.10: Stormwater Management Concept Plan that Incorporates a Variety of Better Site Planning and Design Techniques**
(Source: Atlanta Regional Commission, 2001)

Since the use of better site planning and design techniques can significantly reduce post-construction stormwater runoff rates, volumes and pollutant loads, site planning and design teams need not calculate the stormwater runoff volumes associated with the SWM Criteria that apply to a development site until they have completed an initial layout of the proposed development project. This helps provide the site planning and design team with a "blank canvas" during the creation of the development plan, one which is intended to encourage creativity and the use of a variety of better site planning and design techniques during the layout of the proposed development project. Information about calculating the stormwater runoff volumes associated with the SWM Criteria that apply to a development site is provided in

Section 5.0, while information about applying the stormwater management "credits" associated with each of the better site planning and design techniques is provided in Sections 7.6-7.7.

Once an initial estimate of the stormwater runoff volumes associated with the SWM Criteria that apply to a development site has been completed, the site planning and design team may want to go back to the stormwater management concept plan and apply additional better site design and planning techniques to further reduce post-construction stormwater runoff rates, volumes and pollutant loads. During this iterative site design process, several alternative concept plans can be created (Figures 6.2-6.4) and compared with one another to come up with a plan that will best "fit" the character of the site and best meet the stormwater management and site planning and design criteria presented in this CSS.

#### 6.3.4.4 Step 4.4: Apply Low Impact Development Practices

The next step in the process of developing a stormwater management concept plan is to distribute low impact development practices across the development site. These low impact development practices not only help maintain pre-development site hydrology, by reducing post-construction stormwater runoff rates, volumes and pollutant loads, but also provide a number of other important environmental and economic benefits, including reduced energy demand, urban heat island mitigation, improved aesthetics and improved human health (US EPA, 2008).

The low impact development practices *recommended* for use in coastal Georgia have been divided into three groups: (1) alternatives to disturbed pervious surfaces; (2) alternatives to impervious surfaces; and (3) "receiving" low impact development practices. Each of these groups is briefly described below:

<u>Alternatives to Disturbed Pervious Surfaces</u>

These low impact development practices can be used to help restore disturbed pervious surfaces to their pre-development conditions, which helps reduce post-construction stormwater runoff rates, volumes and pollutant loads. They can be used alone or in combination with one another to restore soils and native vegetative cover in areas that have been or will be disturbed by clearing, grading and other land disturbing activities (Figure 6.11). The alternatives to disturbed pervious surfaces *recommended* for use in coastal Georgia include:

- Soil Restoration
- Site Reforestation/Revegetation

**Figure 6.11: Reforestation of a Disturbed Pervious Area**
(Source: Center for Watershed Protection)

<u>Alternatives to Impervious Surfaces</u>

These low impact development practices can be used to reduce the amount of "effective" impervious cover found on a development site. They can be used in place of traditional impervious surfaces, such as rooftops (Figure 6.12), parking lots and driveways, to reduce the post-construction stormwater runoff rates, volumes and pollutant loads that these surfaces create. The alternatives to impervious surfaces *recommended* for use in coastal Georgia include:

- Green Roofs
- Permeable Pavement

**Figure 6.12: Green Roof Used in Place of a Traditional Impervious Rooftop**
(Source: Center for Watershed Protection)

<u>"Receiving" Low Impact Development Practices</u>

These low impact development practices can be used to "receive" and reduce the post-construction stormwater runoff generated on a development site (Figure 6.13). They are designed to slow and temporarily store stormwater runoff, subjecting it to the runoff reducing hydrologic processes of interception, evapotranspiration, infiltration and capture and reuse, before directing it into the stormwater conveyance system. The low impact development practices that can be used to "receive" post-construction stormwater runoff on a development site include:

- Undisturbed Pervious Areas
- Vegetated Filter Strips
- Grass Channels
- Simple Downspout Disconnection
- Rain Gardens
- Stormwater Planters
- Dry Wells
- Rainwater Harvesting
- Bioretention Areas
- Infiltration Practices
- Dry Swales

**Figure 6.13: Rain Garden Used to "Receive" Stormwater Runoff**
(Source: Center for Watershed Protection)

***Applying Low Impact Development Practices During the Site Planning & Design Process***

After an initial layout of the proposed development project has been completed using better site planning and design techniques (Sections 6.3.4.1-6.3.4.2), and an initial estimate of the stormwater runoff volumes associated with the SWM Criteria that apply to a development site has been completed (Section 6.3.4.3), the site planning and design team should be able to begin distributing low impact development practices across the development site. Many of these practices can be placed in the disturbed and undisturbed pervious areas that were protected earlier in the process through the use of better site planning and design techniques.

At this point in the site planning and design process, a site planning and design team should have a pretty good understanding of the post-construction stormwater runoff rates, volumes and pollutant loads that they will need to manage on the development site. In accordance with SP&D Criteria #2 (Section 4.3.2), it is *recommended* that low impact development practices be used, to the *maximum extent practical*, to reduce these post-construction stormwater runoff rates, volumes and pollutant loads on the development site. Additional information about these low impact development practices, including information about their proper application and design, can be found in Section 7.8.

When applying low impact development practices to a development site, it is important that they be treated just like stormwater management practices. They should be placed in drainage or maintenance easements and included in all stormwater management system inspection and maintenance plans (SP&D Criteria #6).

***Using Low Impact Development Practices to Help Satisfy the Stormwater Management Criteria***

The Center for Watershed Protection (Hirschman et al., 2008) recently documented the ability of low impact development and stormwater management practices to reduce annual stormwater runoff volumes and pollutant loads on development sites (Table 6.3). Based on their ability to provide these measurable reductions in annual stormwater runoff volumes and pollutant loads, all of the low impact development practices *recommended* for use in coastal Georgia have been assigned quantifiable stormwater management "credits" that can be used to help satisfy the SWM Criteria presented in this CSS. While Table 6.4 summarizes all of these "credits," additional information about them, including information about how they can be used to help satisfy the SWM Criteria presented in this CSS, is provided in Section 7.8.

**Table 6.3: Ability of Low Impact Development and Stormwater Management Practices to Reduce Annual Stormwater Runoff Volumes and Pollutant Loads (Source: Hirschman et al., 2008)**

| Practice | Annual Runoff Volume Reduction (%) | Annual Total Phosphorus (TP) Load Removal (%) | Annual Total Nitrogen (TN) Load Removal (%) |
|---|---|---|---|
| Green Roof | 45 to 60 | 45 to 60 | 45 to 60 |
| Rooftop Disconnection | 25 to 50 | 25 to 50 | 25 to 50 |
| Raintanks and Cisterns | 40 | 40 | 40 |
| Permeable Pavement | 45 to 75 | 59 to 81 | 59 to 81 |
| Grass Channel | 10 to 20 | 23 to 32 | 28 to 36 |
| Bioretention | 40 to 80 | 55 to 90 | 64 to 92 |
| Dry Swale | 40 to 60 | 52 to 76 | 55 to 74 |
| Wet Swale | 0 | 20 to 40 | 25 to 35 |
| Infiltration | 50 to 90 | 63 to 93 | 57 to 92 |
| Dry Extended Detention Pond | 0 to 15 | 15 to 28 | 10 to 24 |
| Soil Amendments | 50 to 75 | 50 to 75 | 50 to 75 |
| Sheetflow to Open Space | 50 to 75 | 50 to 75 | 50 to 75 |
| Filtering Practice | 0 | 60 to 65 | 30 to 45 |
| Constructed Wetland | 0 | 50 to 75 | 25 to 55 |
| Wet Pond | 0 | 50 to 75 | 30 to 40 |

| Table 6.4: How Low Impact Development Practices Can Be Used to Help Satisfy the Stormwater Management Criteria | | | | | |
|---|---|---|---|---|---|
| **Low Impact Development Practice** | **Stormwater Runoff Reduction** | **Water Quality Protection** | **Aquatic Resource Protection** | **Overbank Flood Protection** | **Extreme Flood Protection** |
| **Alternatives to Disturbed Pervious Surfaces** | | | | | |
| Soil Restoration | **"Credit":** Subtract 50% of any *restored pervious areas* from the total site area and re-calculate the runoff reduction volume ($RR_v$) that applies to a development site. | **"Credit":** Subtract 50% of any *restored pervious areas* from the total site area and re-calculate the runoff reduction volume ($RR_v$) that applies to a development site. | **"Credit":** Assume that the post-development hydrologic conditions of any *restored pervious areas* are equivalent to those of open space in good condition. | **"Credit":** Assume that the post-development hydrologic conditions of any *restored pervious areas* are equivalent to those of open space in good condition. | **"Credit":** Assume that the post-development hydrologic conditions of any *restored pervious areas* are equivalent to those of open space in good condition. |
| Site Reforestation/ Revegetation | **"Credit":** Subtract 50% of any *reforested/revegetated areas* from the total site area and re-calculate the runoff reduction volume ($RR_v$) that applies to a development site. | **"Credit":** Subtract 50% of any *reforested/revegetated areas* from the total site area and re-calculate the runoff reduction volume ($RR_v$) that applies to a development site. | **"Credit":** Assume that the post-development hydrologic conditions of any *reforested/revegetated areas* are equivalent to those of a similar cover type in fair condition. | **"Credit":** Assume that the post-development hydrologic conditions of any *reforested/revegetated areas* are equivalent to those of a similar cover type in fair condition. | **"Credit":** Assume that the post-development hydrologic conditions of any *reforested/revegetated areas* are equivalent to those of a similar cover type in fair condition. |
| Soil Restoration with Site Reforestation/ Revegetation | **"Credit":** Subtract 100% of any *restored and reforested/ revegetated areas* from the total site area and re-calculate the runoff reduction volume ($RR_v$) that applies to a development site. | **"Credit":** Subtract 100% of any *restored and reforested/ revegetated areas* from the total site area and re-calculate the runoff reduction volume ($RR_v$) that applies to a development site. | **"Credit":** Assume that the post-development hydrologic conditions of any *restored and reforested/ revegetated areas* are equivalent to those of a similar cover type in good condition. | **"Credit":** Assume that the post-development hydrologic conditions of any *restored and reforested/ revegetated areas* are equivalent to those of a similar cover type in good condition. | **"Credit":** Assume that the post-development hydrologic conditions of any *restored and reforested/ revegetated areas* are equivalent to those of a similar cover type in good condition. |
| **Alternatives to Impervious Surfaces** | | | | | |
| Green Roofs | **"Credit":** Reduce the runoff reduction volume ($RR_v$) conveyed through a *green roof* by 60%. | **"Credit":** Reduce the runoff reduction volume ($RR_v$) conveyed through a *green roof* by 60%. | **"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *green roof* when calculating the aquatic resource protection volume ($ARP_v$) on a development site. | **"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *green roof* when calculating the overbank peak discharge ($Q_{p25}$) on a development site. | **"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *green roof* when calculating the extreme peak discharge ($Q_{p100}$) on a development site. |

**Table 6.4: How Low Impact Development Practices Can Be Used to Help Satisfy the Stormwater Management Criteria**

| Low Impact Development Practice | Stormwater Runoff Reduction | Water Quality Protection | Aquatic Resource Protection | Overbank Flood Protection | Extreme Flood Protection |
|---|---|---|---|---|---|
| Permeable Pavement, No Underdrain | **"Credit":** Subtract 100% of the storage volume provided by a non-underdrained *permeable pavement system* from the runoff reduction volume ($RR_v$) conveyed through the *system.* | **"Credit":** Subtract 100% of the storage volume provided by a non-underdrained *permeable pavement system* from the runoff reduction volume ($RR_v$) conveyed through the *system.* | **"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *permeable pavement system* when calculating the aquatic resource protection volume ($ARP_v$) on a development site. | **"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *permeable pavement system* when calculating the overbank peak discharge ($Q_{p25}$) on a development site. | **"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *permeable pavement system* when calculating the extreme peak discharge ($Q_{p100}$) on a development site. |
| Permeable Pavement, Underdrain | **"Credit":** Subtract 50% of the storage volume provided by an underdrained *permeable pavement system* from the runoff reduction volume ($RR_v$) conveyed through the *system.* | **"Credit":** Subtract 50% of the storage volume provided by an underdrained *permeable pavement system* from the runoff reduction volume ($RR_v$) conveyed through the *system.* | | | |
| **"Receiving" Low Impact Development Practices** | | | | | |
| Undisturbed Pervious Areas, A/B Soils | **"Credit":** Reduce the runoff reduction volume ($RR_v$) conveyed through an *undisturbed pervious area* located on A/B soils by 90%. | **"Credit":** Reduce the runoff reduction volume ($RR_v$) conveyed through an *undisturbed pervious area* located on A/B soils by 90%. | **"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by an *undisturbed pervious area* when calculating the aquatic resource protection volume ($ARP_v$) on a development site. | **"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by an *undisturbed pervious area* when calculating the overbank peak discharge ($Q_{p25}$) on a development site. | **"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by an *undisturbed pervious area* when calculating the extreme peak discharge ($Q_{p100}$) on a development site. |
| Undisturbed Pervious Areas, C/D Soils | **"Credit":** Reduce the runoff reduction volume ($RR_v$) conveyed through an *undisturbed pervious area* located on C/D soils by 60%. | **"Credit":** Reduce the runoff reduction volume ($RR_v$) conveyed through an *undisturbed pervious area* located on C/D soils by 60%. | | | |

**Table 6.4: How Low Impact Development Practices Can Be Used to Help Satisfy the Stormwater Management Criteria**

| Low Impact Development Practice | Stormwater Runoff Reduction | Water Quality Protection | Aquatic Resource Protection | Overbank Flood Protection | Extreme Flood Protection |
|---|---|---|---|---|---|
| Vegetated Filter Strips, A/B or Amended Soils | **"Credit":** Reduce the runoff reduction volume ($RR_v$) conveyed through a *vegetated filter strip* located on A/B or amended soils by 60%. | **"Credit":** Reduce the runoff reduction volume ($RR_v$) conveyed through a *vegetated filter strip* located on A/B or amended soils by 60%. | **"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *vegetated filter strip* when calculating the aquatic resource protection volume ($ARP_v$) on a development site. | **"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *vegetated filter strip* when calculating the overbank peak discharge ($Q_{p25}$) on a development site. | **"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *vegetated filter strip* when calculating the extreme peak discharge ($Q_{p100}$) on a development site. |
| Vegetated Filter Strips, C/D Soils | **"Credit":** Reduce the runoff reduction volume ($RR_v$) conveyed through a *vegetated filter strip* located on C/D soils by 30%. | **"Credit":** Reduce the runoff reduction volume ($RR_v$) conveyed through a *vegetated filter strip* located on C/D soils by 30%. | | | |
| Grass Channels, A/B or Amended Soils | **"Credit":** Reduce the runoff reduction volume ($RR_v$) conveyed through a *grass channel* located on A/B or amended soils by 25%. | **"Credit":** Reduce the runoff reduction volume ($RR_v$) conveyed through a *grass channel* located on A/B or amended soils by 25%. | **"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *vegetated filter strip* when calculating the aquatic resource protection volume ($ARP_v$) on a development site. | **"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *vegetated filter strip* when calculating the overbank peak discharge ($Q_{p25}$) on a development site. | **"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *vegetated filter strip* when calculating the extreme peak discharge ($Q_{p100}$) on a development site. |
| Grass Channels, C/D Soils | **"Credit":** Reduce the runoff reduction volume ($RR_v$) conveyed through a *grass channel* located on C/D soils by 12.5%. | **"Credit":** Reduce the runoff reduction volume ($RR_v$) conveyed through a *grass channel* located on C/D soils by 12.5%. | | | |
| Simple Downspout Disconnection, A/B or Amended Soils | **"Credit":** Reduce the runoff reduction volume ($RR_v$) conveyed through a *simple downspout disconnection* located on A/B or amended soils by 60%. | **"Credit":** Reduce the runoff reduction volume ($RR_v$) conveyed through a *simple downspout disconnection* located on A/B or amended soils by 60%. | **"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *simple downspout disconnection* when calculating the aquatic resource protection volume ($ARP_v$) on a development site. | **"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *simple downspout disconnection* when calculating the overbank peak discharge ($Q_{p25}$) on a development site. | **"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *simple downspout disconnection* when calculating the extreme peak discharge ($Q_{p100}$) on a development site. |
| Simple Downspout Disconnection, C/D Soils | **"Credit":** Reduce the runoff reduction volume ($RR_v$) conveyed through a *simple downspout disconnection* located on C/D soils by 30%. | **"Credit":** Reduce the runoff reduction volume ($RR_v$) conveyed through a *simple downspout disconnection* located on C/D soils by 30%. | | | |

**Table 6.4: How Low Impact Development Practices Can Be Used to Help Satisfy the Stormwater Management Criteria**

| Low Impact Development Practice | Stormwater Runoff Reduction | Water Quality Protection | Aquatic Resource Protection | Overbank Flood Protection | Extreme Flood Protection |
|---|---|---|---|---|---|
| Rain Gardens | **"Credit":** Subtract 100% of the storage volume provided by a *rain garden* from the runoff reduction volume ($RR_v$) conveyed through the *rain garden*. | **"Credit":** Subtract 100% of the storage volume provided by a *rain garden* from the runoff reduction volume ($RR_v$) conveyed through the *rain garden*. | **"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *rain garden* when calculating the aquatic resource protection volume ($ARP_v$) on a development site. | **"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *rain garden* when calculating the overbank peak discharge ($Q_{p25}$) on a development site. | **"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *rain garden* when calculating the extreme peak discharge ($Q_{p100}$) on a development site. |
| Stormwater Planters | **"Credit":** Subtract 50% of the storage volume provided by a *stormwater planter* from the runoff reduction volume ($RR_v$) conveyed through the *stormwater planter*. | **"Credit":** Subtract 50% of the storage volume provided by a *stormwater planter* from the runoff reduction volume ($RR_v$) conveyed through the *stormwater planter*. | **"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *stormwater planter* when calculating the aquatic resource protection volume ($ARP_v$) on a development site. | **"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *stormwater planter* when calculating the overbank peak discharge ($Q_{p25}$) on a development site. | **"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *stormwater planter* when calculating the extreme peak discharge ($Q_{p100}$) on a development site. |
| Dry Wells | **"Credit":** Subtract 100% of the storage volume provided by a *dry well* from the runoff reduction volume ($RR_v$) conveyed through the *dry well*. | **"Credit":** Subtract 100% of the storage volume provided by a *dry well* from the runoff reduction volume ($RR_v$) conveyed through the *dry well*. | **"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *dry well* when calculating the aquatic resource protection volume ($ARP_v$) on a development site. | **"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *dry well* when calculating the overbank peak discharge ($Q_{p25}$) on a development site. | **"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *dry well* when calculating the extreme peak discharge ($Q_{p100}$) on a development site. |
| Rainwater Harvesting | **"Credit":** Subtract 75% of the storage volume provided by a *rainwater harvesting system* from the runoff reduction volume ($RR_v$) captured by the *system*. | **"Credit":** Subtract 75% of the storage volume provided by a *rainwater harvesting system* from the runoff reduction volume ($RR_v$) captured by the *system*. | **"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *rainwater harvesting system* when calculating the aquatic resource protection volume ($ARP_v$) on a development site. | **"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *rainwater harvesting system* when calculating the overbank peak discharge ($Q_{p25}$) on a development site. | **"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *rainwater harvesting system* when calculating the extreme peak discharge ($Q_{p100}$) on a development site. |

| Table 6.4: How Low Impact Development Practices Can Be Used to Help Satisfy the Stormwater Management Criteria | | | | | |
|---|---|---|---|---|---|
| **Low Impact Development Practice** | **Stormwater Runoff Reduction** | **Water Quality Protection** | **Aquatic Resource Protection** | **Overbank Flood Protection** | **Extreme Flood Protection** |
| Bioretention Areas, No Underdrain | **"Credit":**<br>Subtract 100% of the storage volume provided by a non-underdrained *bioretention area* from the runoff reduction volume ($RR_v$) conveyed through the *bioretention area*. | **"Credit":**<br>Subtract 100% of the storage volume provided by a non-underdrained *bioretention area* from the runoff reduction volume ($RR_v$) conveyed through the *bioretention area*. | **"Credit":**<br>Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *bioretention area* when calculating the aquatic resource protection volume ($ARP_v$) on a development site. | **"Credit":**<br>Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *bioretention area* when calculating the overbank peak discharge ($Q_{p25}$) on a development site. | **"Credit":**<br>Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *bioretention area* when calculating the extreme peak discharge ($Q_{p100}$) on a development site. |
| Bioretention Areas, Underdrain | **"Credit":**<br>Subtract 50% of the storage volume provided by an underdrained *bioretention area* from the runoff reduction volume ($RR_v$) conveyed through the *bioretention area*. | **"Credit":**<br>Subtract 50% of the storage volume provided by an underdrained *bioretention area* from the runoff reduction volume ($RR_v$) conveyed through the *bioretention area*. | | | |
| Infiltration Practices | **"Credit":**<br>Subtract 100% of the storage volume provided by an *infiltration practice* from the runoff reduction volume ($RR_v$) conveyed through the *infiltration practice*. | **"Credit":**<br>Subtract 100% of the storage volume provided by an *infiltration practice* from the runoff reduction volume ($RR_v$) conveyed through the *infiltration practice*. | **"Credit":**<br>Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by an *infiltration practice* when calculating the aquatic resource protection volume ($ARP_v$) on a development site. | **"Credit":**<br>Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by an *infiltration practice* when calculating the overbank peak discharge ($Q_{p25}$) on a development site. | **"Credit":**<br>Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by an *infiltration practice* when calculating the extreme peak discharge ($Q_{p100}$) on a development site. |
| Dry Swales, No Underdrain | **"Credit":**<br>Subtract 100% of the storage volume provided by a non-underdrained *dry swale* from the runoff reduction volume ($RR_v$) conveyed through the *dry swale*. | **"Credit":**<br>Subtract 100% of the storage volume provided by a non-underdrained *dry swale* from the runoff reduction volume ($RR_v$) conveyed through the *dry swale*. | **"Credit":**<br>Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *dry swale* when calculating the aquatic resource protection volume ($ARP_v$) on a development site. | **"Credit":**<br>Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *dry swale* when calculating the overbank peak discharge ($Q_{p25}$) on a development site. | **"Credit":**<br>Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *dry swale* when calculating the extreme peak discharge ($Q_{p100}$) on a development site. |
| Dry Swales, Underdrain | **"Credit":**<br>Subtract 50% of the storage volume provided by an underdrained *dry swale* from the runoff reduction volume ($RR_v$) conveyed through the *dry swale*. | **"Credit":**<br>Subtract 50% of the storage volume provided by an underdrained *dry swale* from the runoff reduction volume ($RR_v$) conveyed through the *dry swale*. | | | |

### 6.3.4.5 Step 4.5: Check to See If Stormwater Management Criteria Have Been Met

By distributing runoff reducing low impact development practices across a development site (Figure 6.14), and applying the associated stormwater management "credits," it is possible to significantly reduce post-construction stormwater runoff rates, volumes and pollutant loads. Therefore, at this point in the process of developing a stormwater management concept plan, it is *recommended* that site planning and design teams check to see if the SWM Criteria that apply to the development site have been met.

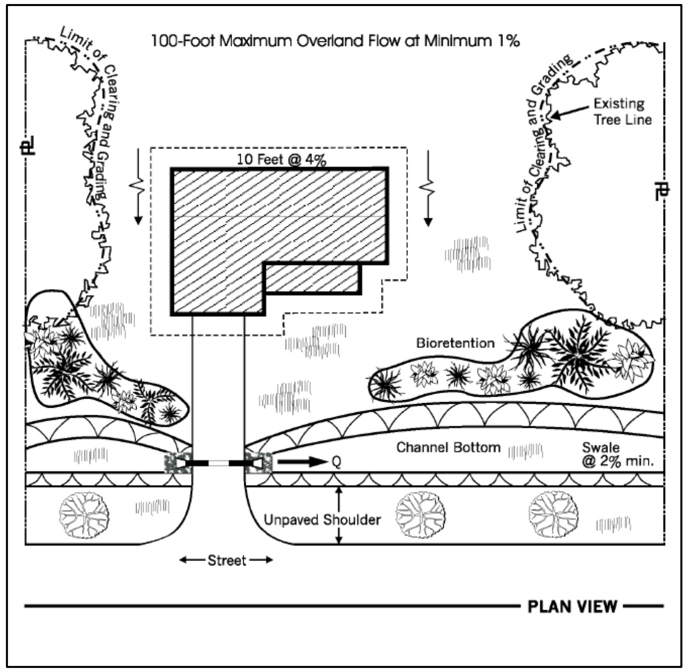


**Figure 6.14: Stormwater Management Concept Plan that Incorporates a Variety of Low Impact Development Practices**
(Source: Prince George's County, MD, 1999)

Depending on the number and type of low impact development practices that have been used, the post-construction stormwater runoff rates, volumes and pollutant loads generated on the development site may have been significantly reduced. If so, the need for larger and more costly stormwater management practices, such as wet ponds and stormwater wetlands, may have been significantly reduced or may have been eliminated altogether. Consequently, site planning and design teams are encouraged to experiment with different combinations of low impact development practices on a development site. They are also encouraged to use low impact development practices in series (e.g., simple downspout disconnection to a dry swale to a bioretention area) to maximize the stormwater management and other environmental benefits that these small-scale stormwater management practices provide.

If, after checking to see if the SWM Criteria have been met, a site planning and design team finds that they have not, they may want to go back to the stormwater management concept plan to apply additional low impact development practices to further reduce post-construction stormwater runoff rates, volumes and pollutant loads on the development site. In accordance with SWM Criteria #1, if low impact development practices, in combination with the previously applied better site planning and design techniques, cannot, on their own, be used to completely satisfy the stormwater runoff reduction criteria (SWM Criteria #1), or any of the other SWM Criteria, stormwater management practices will need to be used on the development site (Section 6.3.4.6).

### 6.3.4.6 Step 4.6: Apply Stormwater Management Practices

Once it has been determined that the SWM Criteria presented in this CSS cannot be satisfied exclusively through the use of green infrastructure practices, the next step in the process of developing a stormwater management concept plan is to use stormwater management practices to further *manage* stormwater runoff rates, volumes and pollutant loads on the development site.

Stormwater management practices (also known as *structural stormwater controls*, *structural stormwater best management practices* or *structural stormwater BMPs*) are engineered facilities designed to *intercept and manage* post-construction stormwater runoff rates, volumes and pollutant loads. The stormwater management practices *recommended* for use in coastal Georgia have been divided into two groups: (1) general application practices (also known as *general application controls*); and (2) limited application practices (also known as *limited application controls* or *detention controls*). Each of these groups is briefly described below:

General Application Practices

General application practices can be used to *treat* stormwater runoff and *manage* the post-construction stormwater runoff rates and volumes generated by larger, less frequent rainfall events (e.g., 1-year, 24-hour event, 25-year, 24-hour event). Several of these practices, namely bioretention areas, infiltration practices and dry swales, can also be used to reduce post-construction stormwater runoff volumes and, consequently, are also classified as runoff reducing low impact development practices (Section 6.3.4.4).

Since they can be used to both *treat* and *manage* post-construction stormwater runoff, it is *recommended* that general application practices be used whenever green infrastructure practices cannot, on their own, be used to completely satisfy the stormwater runoff reduction (SWM Criteria #1), stormwater quality protection (SWM Criteria #2), aquatic resource protection (SWM Criteria #3), overbank flood protection (SWM Criteria #4) and extreme flood protection (SWM Criteria #5) criteria presented in this CSS. The general application practices *recommended* for use in coastal Georgia include:

**Stormwater Ponds**

Stormwater ponds (Figure 6.15) are stormwater detention basins that have a permanent pool of water. Post-construction stormwater runoff is conveyed into the pool, where it is both detained and treated over an extended period of time. The types of stormwater ponds that are *recommended* for use in coastal Georgia include:

**Figure 6.15: Stormwater Pond**
(Source: Atlanta Regional Commission, 2001)

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

**Stormwater Wetlands**

Stormwater wetlands (Figure 6.16) are constructed wetland systems built for stormwater management purposes. Stormwater wetlands typically consist of a combination of open water, shallow marsh and semi-wet areas, and can be used to both detain and treat post-construction stormwater runoff. The types of stormwater wetlands that are *recommended* for use in

**Figure 6.16: Stormwater Wetland**
(Source: Merrill et al., 2006)

coastal Georgia include:

- Shallow Wetlands
- Extended Detention Shallow Wetlands
- Pond/Wetland Systems
- Pocket Wetlands

**Bioretention Areas**

Bioretention areas (Figure 6.17), which may also be classified as a low impact development practice (Section 6.3.4.4), are shallow depressional areas that use an engineered soil mix and vegetation to intercept and treat post-construction stormwater runoff. After passing through a bioretention area, stormwater runoff may be returned to the stormwater conveyance system through an underdrain, or may be allowed to fully or partially infiltrate into the surrounding soils.

**Figure 6.17: Bioretention Area**
(Source: Center for Watershed Protection)

**Filtration Practices**

Filtration practices are multi-chamber structures designed to treat post-construction stormwater runoff using the physical processes of screening and filtration. Sand is typically used as the filter media. After passing through a filtration practice, stormwater runoff is typically returned to the conveyance system through an underdrain. The filtration practices that are *recommended* for use in coastal Georgia include:

- Surface Sand Filter
- Perimeter Sand Filter

**Infiltration Practices**

Infiltration practices (Figure 6.18), which may also be classified as a low impact development practice (Section 6.3.4.4), are shallow excavations, typically filled with stone or an engineered soil mix, that are designed to intercept and temporarily store post-construction stormwater runoff until it infiltrates into the surrounding soils. The infiltration practices that are *recommended* for use in coastal Georgia include:

- Infiltration Trench
- Infiltration Basin

**Figure 6.18: Infiltration Trench**
(Source: Center for Watershed Protection)

**Swales**

Swales (Figure 6.19) are vegetated open channels that are designed to manage post-construction stormwater runoff within a series of linear wet or dry cells formed by check dams or other control structures (e.g., culverts). The two types of swales that are *recommended* for use in coastal Georgia include:

- Dry Swale
- Wet Swale

Because of their ability to reduce annual stormwater runoff volumes and pollutant loads, dry swales may also be classified as a low impact development practice (Section 6.3.4.4).

**Figure 6.19: Wet Swale**
(Source: Center for Watershed Protection)

Limited Application Practices

There are two groups of limited application stormwater management practices that can be used in coastal Georgia, each of which is briefly described below:

**Water Quantity Management Practices**

Water quantity management practices (Figure 6.20) can only be used to *manage* the post-construction stormwater runoff rates and volumes generated by larger, less frequent rainfall events (e.g., 1-year, 24-hour event, 25-year, 24-hour event). They provide little, if any, stormwater runoff reduction or stormwater treatment. Consequently, it is *recommended* that they be used only on a limited basis, and only when green infrastructure practices and general application stormwater management practices cannot be used to completely satisfy the aquatic resource protection (SWM Criteria #3), overbank flood protection (SWM Criteria #4) and extreme flood protection (SWM Criteria #5) criteria presented in this CSS. The water quantity management practices that may be used in coastal Georgia include:

**Figure 6.20: Dry Detention Basin Used to Provide Water Quantity Management**
(Source: Center for Watershed Protection)

- Dry Detention Basins
- Dry Extended Detention Basins
- Multi-Purpose Detention Areas
- Underground Detention Systems

**Water Quality Management Practices**

Water quality management practices can only be used to *treat* post-construction stormwater runoff. They typically have high or special maintenance requirements, provide little, if any, stormwater runoff reduction and cannot be used to *manage* the post-construction stormwater runoff rates and volumes generated by larger, less frequent rainfall events (e.g., 1-year, 24-hour event, 25-year, 24-hour event). Consequently, it is *recommended* that they be used only on a limited basis, and only when green infrastructure practices and general application stormwater management practices cannot be used to completely satisfy the stormwater runoff reduction

(SWM Criteria #1) and stormwater quality protection criteria (SWM Criteria #2) presented in this CSS. The water quality management practices that may be used in coastal Georgia include:

- Organic Filters
- Underground Filters
- Submerged Gravel Wetlands
- Gravity (Oil-Grit) Separators
- Alum Treatment Systems
- Proprietary Systems

***Applying Stormwater Management Practices During the Site Planning & Design Process***

After low impact development practices have been distributed across the development site, and it has been determined that the SWM Criteria that apply to the development site cannot be satisfied exclusively through the use of green infrastructure practices, a site planning and design team should be able to begin applying stormwater management practices to the site to further *manage* post-construction stormwater runoff rates, volumes and pollutant loads. Stormwater management practices should be placed downstream of any previously applied green infrastructure practices to form what are known as "stormwater management trains" (Figure 6.21).

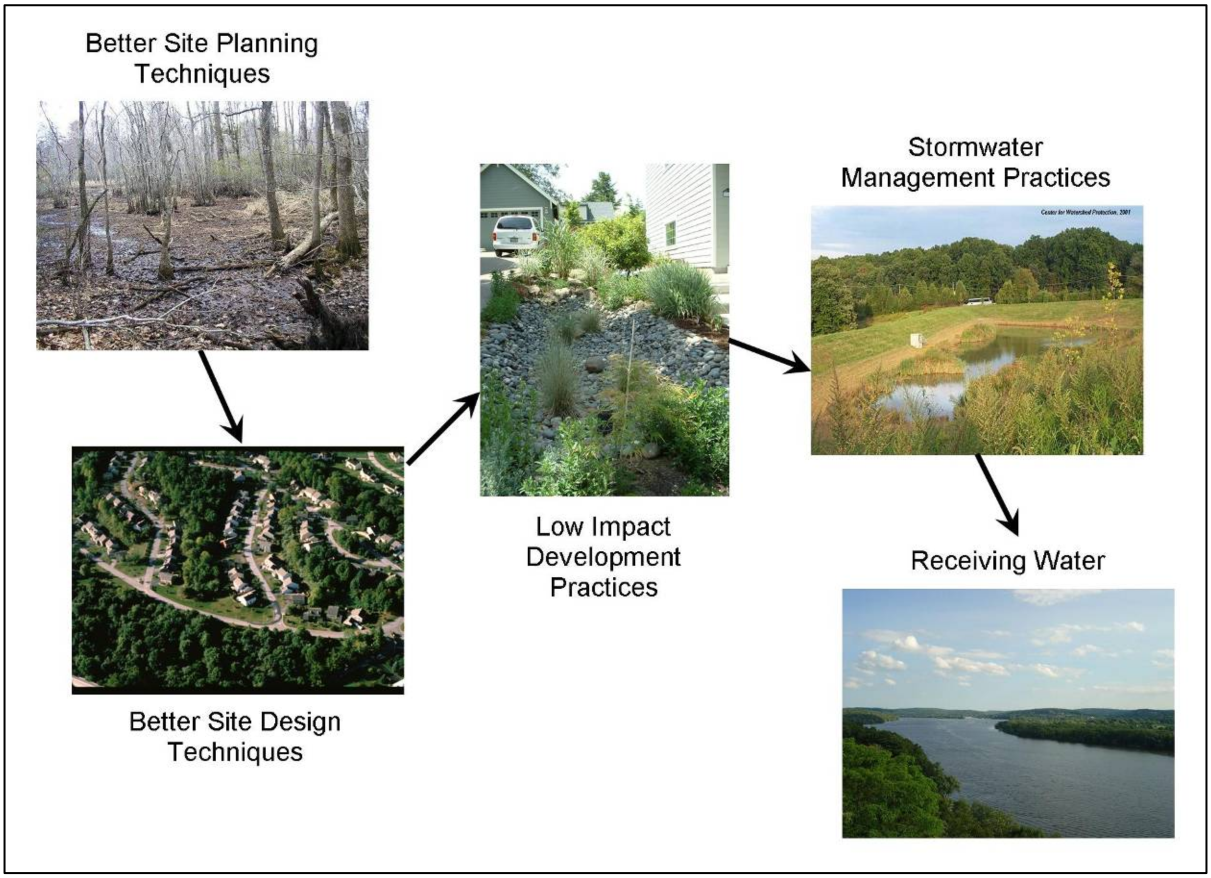


**Figure 6.21: Stormwater Management Train**
(Source: Center for Watershed Protection)

It is important to note that the structure of the "stormwater management train" illustrated in Figure 6.21 mirrors the step-wise process of developing a stormwater management concept plan for a development site. The position of stormwater management practices within the "stormwater management train" reflects the notion that they should not be used on a development site until it has been determined that the SWM Criteria presented in this CSS cannot be satisfied exclusively through the use of green infrastructure practices.

When applying stormwater management practices to a development site, they should be placed in drainage or maintenance easements and included in all stormwater management system inspection and maintenance plans (SP&D Criteria #6). Additional information about the use of stormwater management practices, including information about their proper application and design, can be found in Section 8.6.

***Using Stormwater Management Practices to Help Satisfy the Stormwater Management Criteria***

All of the stormwater management practices *recommended* for use in coastal Georgia have been assigned quantifiable stormwater management "credits" corresponding to the stormwater management benefits that they provide. These "credits" can be used to help satisfy the SWM Criteria presented in this CSS. While Table 6.4 summarizes all of these "credits," additional information about them, including information about how they can be used to help satisfy the SWM Criteria presented in this CSS, is provided in Sections 8.6-8.7.

**Table 6.5: How Stormwater Management Practices Can Be Used to Help Satisfy the Stormwater Management Criteria**

| Stormwater Management Practice | Stormwater Runoff Reduction | Water Quality Protection | Aquatic Resource Protection | Overbank Flood Protection | Extreme Flood Protection |
|---|---|---|---|---|---|
| **General Application Practices** | | | | | |
| Stormwater Ponds | **"Credit":** None | **"Credit":** Assume that a *stormwater pond* provides an 80% reduction in TSS loads[1], a 30% reduction in TN loads[2] and a 70% reduction in bacteria loads[1]. | **"Credit":** A *stormwater pond* can be designed to provide 24-hours of extended detention for the aquatic resource protection volume ($ARP_v$). | **"Credit":** A *stormwater pond* can be designed to attenuate the overbank peak discharge ($Q_{p25}$) on a development site. | **"Credit":** A *stormwater pond* can be designed to attenuate the extreme peak discharge ($Q_{p100}$) on a development site. |
| Stormwater Wetlands | **"Credit":** None | **"Credit":** Assume that a *stormwater wetland* provides an 80% reduction in TSS loads[1], a 30% reduction in TN loads[2] and an 80% reduction in bacteria loads[1]. | **"Credit":** A *stormwater wetland* can be designed to provide 24-hours of extended detention for the aquatic resource protection volume ($ARP_v$). | **"Credit":** A *stormwater wetland* can be designed to attenuate the overbank peak discharge ($Q_{p25}$) on a development site. | **"Credit":** A *stormwater wetland* can be designed to attenuate the extreme peak discharge ($Q_{p100}$) on a development site. |
| Bioretention Areas, No Underdrain | **"Credit":** Subtract 100% of the storage volume provided by a non-underdrained *bioretention area* from the runoff reduction volume ($RR_v$) conveyed through the *bioretention area*. | **"Credit":** Assume that a *bioretention area* provides an 80% reduction in TSS loads[1], a 60% reduction in TN loads[2] and an 80% reduction in bacteria loads[#]. | **"Credit":** Although uncommon, on some development sites, a *bioretention area* can be designed to provide 24-hours of extended detention for the aquatic resource protection volume ($ARP_v$). | **"Credit":** Although relatively rare, on some development sites, a *bioretention area* can be designed to attenuate the overbank peak discharge ($Q_{p25}$). | **"Credit":** Although relatively rare, on some development sites, a *bioretention area* can be designed to attenuate the extreme peak discharge ($Q_{p100}$). |
| Bioretention Areas, Underdrain | **"Credit":** Subtract 50% of the storage volume provided by an underdrained *bioretention area* from the runoff reduction volume ($RR_v$) conveyed through the *bioretention area*. | | | | |

**Table 6.5: How Stormwater Management Practices Can Be Used to Help Satisfy the Stormwater Management Criteria**

| Stormwater Management Practice | Stormwater Runoff Reduction | Water Quality Protection | Aquatic Resource Protection | Overbank Flood Protection | Extreme Flood Protection |
|---|---|---|---|---|---|
| Filtration Practices | **"Credit":** None | **"Credit":** Assume that a *filtration practice* provides an 80% reduction in TSS loads[1], a 30% reduction in TN loads[2] and a 40% reduction in bacteria loads[1]. | **"Credit":** Although uncommon, on some development sites, a *filtration practice* can be designed to provide 24-hours of extended detention for the aquatic resource protection volume ($ARP_v$). | **"Credit":** Although relatively rare, on some development sites, a *filtration practice* can be designed to attenuate the overbank peak discharge ($Q_{p25}$). | **"Credit":** Although relatively rare, on some development sites, a *filtration practice* can be designed to attenuate the extreme peak discharge ($Q_{p100}$). |
| Infiltration Practices | **"Credit":** Subtract 100% of the storage volume provided by an *infiltration practice* from the runoff reduction volume ($RR_v$) conveyed through the *infiltration practice*. | **"Credit":** Assume that an *infiltration practice* provides an 80% reduction in TSS loads[1], an 60% reduction in TN loads[2] and an 80% reduction in bacteria loads[#]. | **"Credit":** Although uncommon, on some development sites, an *infiltration practice* can be designed to provide 24-hours of extended detention for the aquatic resource protection volume ($ARP_v$). | **"Credit":** Although relatively rare, on some development sites, an *infiltration practice* can be designed to attenuate the overbank peak discharge ($Q_{p25}$). | **"Credit":** Although relatively rare, on some development sites, an *infiltration practice* can be designed to attenuate the extreme peak discharge ($Q_{p100}$). |
| Dry Swales, No Underdrain | **"Credit":** Subtract 100% of the storage volume provided by a non-underdrained *dry swale* from the runoff reduction volume ($RR_v$) conveyed through the *dry swale*. | **"Credit":** Assume that a *dry swale* provides an 80% reduction in TSS loads[1], a 50% reduction in TN loads[2] and a 60% reduction in bacteria loads[#]. | **"Credit":** Although uncommon, on some development sites, a *dry swale* can be designed to provide 24-hours of extended detention for the aquatic resource protection volume ($ARP_v$). | **"Credit":** Although relatively rare, on some development sites, a *dry swale* can be designed to attenuate the overbank peak discharge ($Q_{p25}$). | **"Credit":** Although relatively rare, on some development sites, a *dry swale* can be designed to attenuate the extreme peak discharge ($Q_{p100}$). |
| Dry Swales, Underdrain | **"Credit":** Subtract 50% of the storage volume provided by an underdrained *dry swale* from the runoff reduction volume ($RR_v$) conveyed through the *dry swale*. | | | | |
| Wet Swales | **"Credit":** None | **"Credit":** Assume that a *wet swale* provides an 80% reduction in TSS loads[1], a 25% reduction in TN loads[2] and a 40% reduction in bacteria loads[#]. | **"Credit":** Although uncommon, on some development sites, a *wet swale* can be designed to provide 24-hours of extended detention for the aquatic resource protection volume ($ARP_v$). | **"Credit":** Although uncommon, on some development sites, a *wet swale* can be designed to attenuate the overbank peak discharge ($Q_{p25}$). | **"Credit":** Although uncommon, on some development sites, a *wet swale* can be designed to attenuate the extreme peak discharge ($Q_{p100}$). |

**Table 6.5: How Stormwater Management Practices Can Be Used to Help Satisfy the Stormwater Management Criteria**

| Stormwater Management Practice | Stormwater Runoff Reduction | Water Quality Protection | Aquatic Resource Protection | Overbank Flood Protection | Extreme Flood Protection |
|---|---|---|---|---|---|
| **Limited Application Practices** | | | | | |
| **Water Quantity Management Practices** | | | | | |
| Dry Detention Basins | **"Credit":** None | **"Credit":** None | **"Credit":** None | **"Credit":** A *dry detention basin* can be used to attenuate the overbank peak discharge ($Q_{p25}$) on a development site. | **"Credit":** A *dry detention basin* can be used to attenuate the extreme peak discharge ($Q_{p100}$) on a development site. |
| Dry Extended Detention Basins | **"Credit":** None | **"Credit":** Assume that a *dry extended detention basin* provides a 40% reduction in TSS loads[1], a 10% reduction in TN loads[2] and a 20% reduction in bacteria loads[#]. | **"Credit":** A *dry extended detention basin* can be used to provide 24-hours of extended detention for the aquatic resource protection volume ($ARP_V$). | **"Credit":** A *dry extended detention basin* can be used to attenuate the overbank peak discharge ($Q_{p25}$) on a development site. | **"Credit":** A *dry extended detention basin* can be used to attenuate the extreme peak discharge ($Q_{p100}$) on a development site. |
| Multi-Purpose Detention Areas | **"Credit":** None | **"Credit":** None | **"Credit":** None | **"Credit":** A *multi-purpose detention area* can be used to attenuate the overbank peak discharge ($Q_{p25}$) on a development site. | **"Credit":** A *multi-purpose detention area* can be used to attenuate the overbank peak discharge ($Q_{p25}$) on a development site. |
| Underground Detention Systems | **"Credit":** None | **"Credit":** None | **"Credit":** An *underground detention system* can be used to provide 24-hours of extended detention for the aquatic resource protection volume ($ARP_V$). | **"Credit":** An *underground detention system* can be used to attenuate the overbank peak discharge ($Q_{p25}$) on a development site. | **"Credit":** An *underground detention system* can be used to attenuate the extreme peak discharge ($Q_{p100}$) on a development site. |
| **Water Quality Management Practices** | | | | | |
| Organic Filters | **"Credit":** None | **"Credit":** Assume that an *organic filter* provides an 80% reduction in TSS loads[3], a 40% reduction in TN loads[3] and a 40% reduction in bacteria loads[1]. | **"Credit":** None | **"Credit":** None | **"Credit":** None |

| Table 6.5: How Stormwater Management Practices Can Be Used to Help Satisfy the Stormwater Management Criteria | | | | | |
|---|---|---|---|---|---|
| **Stormwater Management Practice** | **Stormwater Runoff Reduction** | **Water Quality Protection** | **Aquatic Resource Protection** | **Overbank Flood Protection** | **Extreme Flood Protection** |
| Underground Filters | **"Credit":** None | **"Credit":** Assume that an *underground filter* provides an 80% reduction in TSS loads[1], a 30% reduction in TN loads[1] and a 40% reduction in bacteria loads[1]. | **"Credit":** None | **"Credit":** None | **"Credit":** None |
| Submerged Gravel Wetlands | **"Credit":** None | **"Credit":** Assume that a *submerged gravel wetland* provides an 80% reduction in TSS loads[3], a 20% reduction in TN loads[3] and a 40% reduction in bacteria loads[#]. | **"Credit":** None | **"Credit":** None | **"Credit":** None |
| Gravity (Oil-Grit) Separators | **"Credit":** None | **"Credit":** Assume that a *gravity (oil-grit) separator* provides a 40% reduction in TSS loads[#], a 10% reduction in TN loads[#] and a 20% reduction in bacteria loads[#]. | **"Credit":** None | **"Credit":** None | **"Credit":** None |
| Alum Treatment Systems | **"Credit":** None | **"Credit":** Assume that an *alum treatment system* provides a 90% reduction in TSS loads[4], a 60% reduction in TN loads[4] and a 90% reduction in bacteria loads[4]. | **"Credit":** None | **"Credit":** None | **"Credit":** None |
| Proprietary Systems | **"Credit":** TBD* | **"Credit":** TBD* | **"Credit":** TBD* | **"Credit":** TBD* | **"Credit":** TBD* |

Notes:
1 National Pollutant Removal Database, Version 3.0 (Fraley-McNeil, 2007)
2 Runoff Reduction Technical Memorandum (Hirschman et al., 2008)
3 National Pollutant Removal Database, Version 2.0 (Winer, 2000)
4 Georgia Stormwater Management Manual, Volume 2 (ARC, 2001)
# Load reduction estimates are based on a very limited amount of data and should be considered to be provisional estimates.
* Information about how specific proprietary devices and systems can be used to help satisfy the stormwater management criteria must be provided by the manufacturer and should be verified using independently-reviewed performance monitoring data and calculations. See Appendix D for more information about monitoring the performance of individual stormwater management practices.

#### 6.3.4.7 Step 4.7: Check to See If Stormwater Management Criteria Have Been Met

Once stormwater management practices have been applied to a development site, site planning and design teams should check to make sure that all of the SWM Criteria that apply to the site have been completely satisfied. If the SWM Criteria have not been met, teams will need to go back to the stormwater management concept plan and apply additional low impact development and stormwater management practices to further *reduce* and *manage* post-construction stormwater runoff rates, volumes and pollutant loads on the development site.

On many development sites, the process of developing a stormwater management concept plan will be an iterative process. When compliance with the SWM Criteria presented in this CSS is not achieved on the first try, site planning and design teams should return to earlier steps in process to explore alternative site layouts and different combinations of green infrastructure and stormwater management practices. By periodically checking to see if the SWM Criteria that apply to the development site have been met (e.g., Step 4.3, Step 4.5), they can significantly reduce the amount of time that this iterative site design process will take.

If the SWM Criteria presented in this CSS cannot, due to site characteristics or constraints, be satisfied through the use of *on-site* green infrastructure and stormwater management practices, site planning and design teams may be able to achieve compliance by implementing or contributing to an *off-site* stormwater management project. Off-site projects can be an extremely attractive compliance option on redevelopment sites where space for on-site green infrastructure and stormwater management practices is extremely limited. If a developer is interested in using an off-site stormwater management project to help satisfy the SWM Criteria presented in this CSS, they are encouraged to consult with the local development review authority.

#### 6.3.4.8 Step 4.8: Finalize Stormwater Management Concept Plan

Once the SWM Criteria that apply to the development site have been completely satisfied, the next step in the process of developing a stormwater management concept plan is to finalize the plan. In accordance with SP&D Criteria #3 (Section 4.3.3), the final version of the stormwater management concept plan should illustrate the layout of the proposed development project and should show, in general, how post-construction stormwater runoff will be managed on the development site. It is *recommended* that the stormwater management concept plan include all of the information outlined in Section 4.3.3.

The stormwater management concept plan should be submitted to the local development review authority prior to the preparation and submittal of a stormwater management design plan (Section 6.3.6). This provides the local development review authority with an opportunity to provide feedback on the proposed post-construction stormwater management before additional resources are used to create a more detailed stormwater management plan.

### 6.3.5 Step 5: Consultation Meeting

Once a stormwater management concept plan has been created, it is *recommended* that the site planning and design team hold a consultation meeting with the local development review authority. This meeting, which should occur right after completion of the stormwater management concept plan, provides an opportunity to discuss the proposed development project and the approach that was used to satisfy the stormwater management and site planning and design criteria that apply to the development site. If representatives from appropriate state and federal agencies are able to attend the meeting, it can also be to review and discuss the state and federal regulations (e.g., Coastal Marshlands Protection Act, Georgia Erosion and Sediment Control Act, Clean Water Act, Endangered Species Act) that apply to the proposed development project.

If possible, the consultation meeting should take place on the development site after submittal, but prior to approval, of the *stormwater management concept plan*. When conducted on the development site, the consultation meeting can be used to verify site conditions and the feasibility of the proposed *stormwater management concept plan*.

### 6.3.6 Step 6: Prepare Stormwater Management Design Plan

Subsequent to review and approval of the stormwater management concept plan, the site planning and design team should prepare a stormwater management design plan. In accordance with SP&D Criteria #4 (Section 4.3.4), the stormwater management design plan should detail how post-construction stormwater runoff will be managed on the development site and should include maps, narrative descriptions and design calculations (e.g., hydrologic and hydraulic calculations) that show how the stormwater management and site planning and design criteria that apply to the development project have been met. It is *recommended* that the stormwater management design plan include all of the information outlined in Section 4.3.4.

The stormwater management design plan should be submitted to the local development review authority for review and approval. The following information should be submitted to the local development review authority along with the stormwater management design plan:

- Plan preparer certification (Box 6.2)

| Box 6.2: Example Plan Preparer Certification |
|---|
| "I, (NAME OF PROFESSIONAL), a Registered (PROFESSIONAL ENGINEER/LAND SURVEYOR/LANDSCAPE ARCHITECT) in the state of Georgia, hereby certify that this stormwater management design plan for the project known as (PROJECT NAME), in (CITY NAME), (COUNTY NAME), Georgia, has been prepared under my supervision, and, in my opinion, meets the stormwater management and site planning and design criteria presented in the Coastal Stormwater Supplement. This (DAY) day of (MONTH), (YEAR)." |

- Owner/developer certification (Box 6.3)

| Box 6.3: Example Owner/Developer Certification |
|---|
| "I, (NAME OF OWNER/DEVELOPER), hereby certify that all clearing, grading, construction and land disturbing activities for the project known as (PROJECT NAME), in (CITY NAME), (COUNTY NAME), Georgia, will be performed according this stormwater management design plan. This (DAY) day of (MONTH), (YEAR)." |

- Downstream analysis, prepared in accordance with SP&D Criteria #5 (Section 4.3.5)
- Stormwater management inspection and maintenance plan, prepared in accordance with SP&D Criteria #6 (Section 4.3.6)
- Erosion and sediment control plan, prepared in accordance with SP&D Criteria #7 (Section 4.3.7)
- Landscaping plan, prepared in accordance with SP&D Criteria #8 (Section 4.3.8)
- If necessary, stormwater pollution prevention plan, prepared in accordance with SP&D Criteria #9 (Section 4.3.9)

A copy of the stormwater management concept plan should be submitted along with the stormwater management design plan. The stormwater management design plan should be consistent with the stormwater management concept plan. If any significant changes were made to the plan of development, the local development review authority may ask for a written statement providing rationale for any changes that were made.

It is *recommended* that the site planning and design team apply for any applicable state or federal permits (e.g., Coastal Marshlands Protection Act, Georgia Erosion and Sediment Control Act, Clean Water Act, Endangered Species Act) prior to, or in conjunction with, the submittal of the stormwater management design plan to the local development review authority. In some cases, state or federal agencies or the local development review authority may require that the stormwater management design plan be changed or revised. This may lengthen the amount of time that it takes to complete the site planning and design process. However, if the six-step *stormwater management planning and design process* outlined above (Figure 6.5) is used to create the stormwater management design plan, there is a good chance that permits will be more quickly obtained from local, state and federal review agencies.

### 6.3.7 Beyond the Stormwater Management Design Plan

Once the stormwater management design plan has been reviewed and approved by the local development review authority and any applicable state or federal agencies, performance bonds may be set and placed, contractors retained and construction initiated. During the construction phase, the development site is typically inspected on a regular basis by the local development review authority to ensure that all roadways, parking areas, buildings, utilities and other infrastructure, including all green infrastructure and stormwater management practices, are being built in accordance with the approved stormwater management design plan and that all primary and secondary conservation areas are being adequately protected from the land development process.

Once construction is complete, final inspections typically take place to ensure that all roadways, parking areas, buildings, utilities and other infrastructure, including the post-construction stormwater management system, were built according to the approved final plan. As-built plans are also typically prepared and executed during this phase. If a development project passes all final inspections, an occupancy permit may be issued for the project.

## 6.4 Meeting the Stormwater Management and Site Planning and Design Criteria on Local Road, Highway and Bridge Development Projects

Since they are often designed to discharge stormwater runoff directly into streams, wetlands and other aquatic resources, local road, highway and bridge development projects can have significant negative impacts on the valuable aquatic resources of coastal Georgia. Without an effort to control and minimize these impacts, these development projects have the potential to significantly impair the very natural resources that contribute so greatly to the region's natural beauty, economic well-being and quality of life.

Although the integrated, green infrastructure-based approach to natural resource protection, stormwater management and site design detailed in this CSS can be used to help balance the protection of coastal Georgia's valuable terrestrial and aquatic resources with local road, highway and bridge development projects, managing post-construction stormwater runoff on these projects typically presents some challenges for site planning and design teams, including:

- The need to manage the significant stormwater runoff volumes generated on impervious roadway surfaces
- The need to locate stormwater management practices in a limited amount of space (e.g,. rights-of-way)
- The need to manage stormwater runoff while maintaining safe driving conditions
- The need to manage and contain potential spills

Despite these challenges, many of the natural resource protection and stormwater management practices and techniques discussed above can be successfully applied on local road, highway and bridge development projects. However, there are a number of site characteristics and constraints that should be considered when planning and designing of one of these projects to ensure that the prescribed green infrastructure and stormwater management practices will continue to function, as designed, over time (PA DEP, 2006):

- Roadway runoff typically contains higher pollutant loads than stormwater runoff from other urban land uses (Bannerman et al., 1993, Steuer et al., 1997). Sediment loads can be especially high on dirt and gravel roads. Consequently, roadway runoff should *not* be managed with infiltration practices, unless pretreatment is used to reduce sediment loads before stormwater runoff reaches them. Infiltration practices that are applied to local road, highway and bridge development projects must be preceded by green infrastructure or stormwater management practices that can significantly reduce sediment loads, such as:

    - Undisturbed Natural Areas
    - Vegetated Filter Strips
    - Grass Channels
    - Swales
    - Bioretention Areas
    - Filtration Practices

  Using green infrastructure and stormwater management practices that reduce sediment loads upstream of infiltration practices helps reduce the risk of clogging and practice failure.

- Grass channels and swales can be highly effective at providing both stormwater conveyance and stormwater runoff reduction. Because they can typically be designed to fit within the right-of-way, they are ideal for use on local road, highway and bridge development projects. However, they must be properly designed to prevent erosion and reduce the amount of maintenance that they will require over time. Additional information about these practices, including information about their proper application and design, is provided in Sections 7.8 and 8.6 of this CSS.

- The potential for spills should be considered during the planning and design process used for local road, highway and bridge development projects. While it is not practical to design for spill containment on all local roads and highways, the site designer should at least consider the potential for spills and the remedial actions that will become necessary should a spill occur.

  Many green infrastructure and stormwater management practices, including filter strips, swales, filtration and infiltration practices and bioretention areas, will require significant maintenance or complete replacement after a spill occurs. While this may discourage the site designer from using these practices on local road development projects where spills are a concern, the relatively minor cost of replacing these stormwater management practices is worth the spill protection they provide. The alternative to using these green infrastructure and stormwater management practices is conveying the pollution generated by spills directly to streams, wetlands and other aquatic resources through the storm drain system, which can result in very high clean up and remediation costs.

- Increased stormwater runoff temperatures can result from local road, highway and bridge development projects. As stormwater runoff moves over these impervious surfaces, it increases in temperature. As documented in Section 3.3.2, when this "heated" stormwater runoff is conveyed into a river, stream, wetland or other aquatic resource, it can decrease the amount of dissolved oxygen contained within the water column, which reduces the amount of oxygen available to aquatic organisms. Consequently, site planning and design teams working on local road, highway and bridge development projects should consider the use of green infrastructure and stormwater management practices that promote infiltration and reduce stormwater runoff temperatures, including:

    - Protect Primary Conservation Areas
    - Protect Secondary Conservation Areas
    - Reduce Clearing and Grading Limits
    - Soil Restoration
    - Site Reforestation/Revegetation
    - Vegetated Filter Strips
    - Grass Channels
    - Swales
    - Bioretention Areas
    - Infiltration Practices

There are certain green infrastructure and stormwater management practices that work particularly well on local road development projects, others that work particularly well on local highway development projects and still others that work particularly well on local bridge development projects. The green infrastructure and stormwater management practices that can be most readily applied to each of these different types of development projects are briefly described below.

### 6.4.1 Local Highway Development Projects

Local highways are often designed with grass shoulders and often include vegetated medians, providing plenty of room for the use of green infrastructure and stormwater management practices. Opportunities to use infiltration practices on highway development projects, however, may be limited due to extensive grading and earthwork, as highway rights-of-way are often subject to significant compaction. However, the use of infiltration practices should not automatically be ruled out on local highway development projects, and should be considered on a case-by-case basis.

Because they can typically be designed to fit within medians and shoulders, swales, grass channels and vegetated filter strips are ideal for use on local highway development projects. They can be combined with bioretention areas located within the right-of-way to provide additional runoff reduction or with larger stormwater management practices, such as stormwater ponds and stormwater wetlands, to manage the peak stormwater runoff rates and volumes generated by larger, less frequent storm events.

### 6.4.2 Local Bridge Development Projects

Since bridges are built directly over streams and other aquatic resources, there is often little opportunity to use green infrastructure and stormwater management practices on these development projects. However, the use of filtration practices, particularly perimeter sand filters, as well as proprietary water quality management practices should be considered, as these stormwater management practices can be used to treat stormwater runoff before it is discharged directly from a bridge deck into a stream, wetland or other aquatic resource.

### 6.4.3 Local Street and Roadway Development Projects

Local street and roadway development projects are ideal for the use of green infrastructure and stormwater management practices. Although the goal of these natural resource protection and stormwater management practices and techniques is not just to minimize the creation of new impervious and disturbed pervious cover, a number of better site design techniques do work particularly well on these development projects, including:

- Reduce Clearing and Grading Limits
- Reduce Roadway Lengths and Widths
- Reduce Sidewalk Lengths and Widths
- Use Fewer or Alternative Cul-de-Sacs

Unfortunately, the use of some of these better site design techniques may be restricted by local "development rules." Site planning and design teams are encouraged to identify any local restrictions that would preclude the use of any of these better site design techniques on local street and roadway development projects.

Another site design technique that works particularly well on local street and roadway development projects is to use the right-of-way, rather than curbs and gutters, to manage post-construction stormwater runoff. Open section roadways can be used in place of closed section roadways to allow stormwater runoff to sheet flow off of the pavement surface and into grass channels, dry swales, vegetated filter strips or undisturbed pervious areas, all of which provide significant reductions in post-construction stormwater runoff rates, volumes and pollutant loads. Other green infrastructure and stormwater management practices that can be applied on local street and roadway development projects include:

- Permeable Pavement
- Bioretention Areas
- Filtration Practices
- Infiltration Practices
- Wet Swales

### 6.4.4 Local Back (Dirt and Gravel) Road Development Projects

A significant portion of coastal Georgia is served by unpaved dirt and gravel roads. These roads, and their associated stormwater conveyance systems (e.g., ditches, culverts), are prone to erosion and can generate significant amounts of stormwater pollution. In fact, according to the Georgia Department of Natural Resources Environmental Protection Division (GA EPD), the sediment generated on local dirt and gravel roads ranks second only to row cropping as a source of sediment in the state of Georgia (Pine Country RCDC, 2008). Consequently, it is important to manage the post-construction stormwater runoff generated on these unpaved surfaces to help protect the streams, wetlands and other aquatic resources of coastal Georgia from the negative impacts of the land development process. Although all of the techniques discussed below can be used to manage the stormwater runoff generated on these unpaved surfaces, additional guidance on managing local dirt and gravel road development projects can be obtained through the Georgia Better Back Roads Program. Additional information about this program can be found on the following website: http://www.tworiversrcd.org/GABBR.htm.

One of the simplest ways to control and minimize the negative impacts of local back road development projects is to use better site planning and design techniques during their design. By working with existing topography and natural drainage divides and patterns, roadway planning and design teams can minimize the need for earthwork, as well as the need for culverts and stream crossings.

Another simple technique that can be used to reduce the negative impacts of local back road development projects is to crown the roadways to prevent water from ponding on the roadway surface itself. On these crowned dirt and gravel roadways, stormwater runoff can be allowed to sheet flow off of the roadway surface and into undisturbed natural areas, vegetated filter strips, grass channels and dry swales, all of which provide significant reductions in post-development stormwater runoff rates, volumes and pollutant loads. Moving stormwater off of the surface of these roads also helps prevent the formation of erosive conditions.

Care should be taken to ensure that the green infrastructure and stormwater management practices that are designed to “receive” stormwater runoff from dirt and gravel roadways are properly designed and maintained. Any vegetation that is planted within these green infrastructure and stormwater management practices should be maintained over time, as it helps stabilize soils and prevent soil erosion. Because of the significant sediment loads that these roadways can generate, runoff from dirt and gravel roadways *should not* be managed with infiltration practices, unless pretreatment is used to reduce sediment loads before stormwater runoff reaches these infiltration practices.

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