City of Ormond Beach

Low Impact Development Design Manual

City of Ormond Beach

Planning Department

1sr Edition - 2013

City of Ormond Beach
Low Impact Development Manual

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Section 1
Introduction to Low Impact Development in the City of Ormond Beach

Section 1.0: Administration

This manual has been prepared to aid developers, development design professionals, contractors, property managers, and City review and administrative personnel to implement successful Low Impact Development (LID) projects within the City of Ormond Beach. Specific reference is made to this manual, and authorization is made for its implementation in Chapter 3, Article 2, Section 3-18: Surface Water Control, of the Land Development Code for the City of Ormond Beach Florida.

Section 1.1: Introduction to Low Impact Development

The discipline of Stormwater Management has, by nature, been a component of Public Works and Land Development that has experienced a constant state of evolution since its earliest implementation. Early man realized that by controlling irrigation individuals and societies could provide for increased agricultural success and consistency. As populations became more urban and development lead to areas of greater intensity, the need for methods of flood control to protect population and property became the focus of stormwater management; recent trends in stormwater management have centered on methods that prevent pollution from runoff, and protect natural resources, specifically downstream water bodies and wetland systems.

These recent shifts in stormwater management techniques, placing a greater emphasis upon pollution abatement have also lead to greater research in methods and a higher level of critique in measurement of the success of specific practices and the overall stormwater management systems that have become commonplace and accepted in design. Many of these studies have shown that the performance of these systems have not met the efficiencies in pollutant removal that was anticipated and expected from them. The result of these advanced studies have made it apparent that revisions to the way developers approach stormwater management and the way jurisdictions regulate these systems require more complex systems that more closely mimic nature in their provision for environmental protection, flood control, and that can, in many instances, bring a return to our beginnings with the use of collected runoff for irrigation of the green areas incorporated into our sites.

This manual is intended to be a dynamic document for use by the City of Ormond Beach and those who develop sites within the City. As technology and research provide greater insight and solutions for the development of stormwater management techniques that mimic nature both in treatment quality and runoff control, additions and modifications can and should be made to this handbook. That being said, this manual is not intended to replace the rules and ordinances of the City of Ormond Beach, County of Volusia, St. Johns River Water Management District, or other jurisdictional agencies that may govern stormwater management on any given site within the limits of the City. Utilization of Low Impact Design (LID) techniques often requires taking steps that are beyond the minimum design standards; as such, there are no specific requirements that mandate the use of LID on any given development or redevelopment site. Those interested in applying the principles of Low Impact Development (LID) into their site design are taking steps that are beyond those expected of sites utilizing traditional best management practices.

Section 1.2: Low Impact Development

Low Impact Development (LID) is a term that represents stormwater management and the comprehensive approach to land development required to mimic the inherent nature of a site's hydrology and the interface of the subject property with the lands, waters, and natural systems downstream from the property.

In order to achieve the ultimate goal of improving upon the efficiency of traditional stormwater management, the LID approach decentralizes the traditional "bottom of the hill" method of treatment and attenuation and manages the process at the source of runoff through the use of the small scale treatment techniques; connected in what is often referred to as a "Treatment Train".

These multiple elements are referred to as Integrated Management Practices (IMPs) and provide for a system that does not simply collect and convey runoff but rather provides for and encourages the infiltration, filtration, storage, evaporation, of runoff detaining it close to the source. When incorporating Integrated Management Practices into site development the project design professional should utilize the following principles of Low Impact Development that can guide the project design and achieve a successful sustainable site.

1. Conservation of natural resources and site characteristics that provide natural functions associated with controlling, filtering, conveying, and storing stormwater
2. Minimization and disconnection of impervious surfaces.
3. Use of distributed small scale controls to route flows, control discharge, and mimic the site's pre-development hydrology to the maximum possible extent.
4. Maintain the pre-development travel time (time of concentration) by routing flows and controlling discharge in the post development condition.
5. Direct runoff to natural and created landscape areas that are conducive to infiltration.
6. Provide a program of public information to the property owners, employees, and residents / tenants.

When using this handbook, it should be apparent that utilizing LID techniques in the design of a site requires the design professional to apply the techniques of Low Impact Design beginning in the early stages development starting with site selection and conceptual layout, continuing through site design, construction of the system and ultimately operation and maintenance of the site. **Low Impact Design is not an off the shelf approach that can be applied from one site to another. Existing site conditions for a project, both new construction and re-development of an existing site will dictate the selection, arrangement, and sizing of IMPs best suited for a given site. Not every site is conducive to the use of LID and the specific elements associated with its use.** It is the intention of this handbook to provide a guide for users as they utilize of the techniques associated with LID and develop projects that minimize the impact made by the project from the property in its natural state.

Section 1.3: Outline of this Manual

The purpose of this manual is to provide the toolbox for those designing stormwater systems using Low Impact Development Techniques within the City of Ormond Beach. However, this manual is intended to be used not only by the Engineers and Planners responsible for site development design but also the property developer / owner, City of Ormond Beach regulation officials, site contractors as well as those responsible for the operation of the site upon completion including maintenance staff, residents, and others associated with the site.

This organization of this handbook is divided into the following four divisions:

- **Section 1 – The introduction to the using Low Impact Development and its techniques for development in the City of Ormond Beach.**
  This section provides starts the discussion, introducing LID in the context of Land Development within Ormond Beach.

- **Section 2 – Presentation of Low Impact Design theory, methodology, and how it is implementated into a project.**
  This section will examine the design process and the evaluation of a site with focus on specific LID practices and how these LID principles can be incorporated into specific projects. It will discuss acceptable techniques for LID as well as advantages and concessions that can be made when developers and design professionals use LID in their planned project. A brief overview of the stormwater criteria that will be applied to project electing to include LID techniques in their design will also be addressed.

- **Section 3 – LID Toolbox**
  This section considers the technical elements of Low Impact Design. It is in this section that specific treatment techniques will be described in greater detail and presented with design aids including equations, photos and design details that can be incorporated into the plans for development of the site.

- **Section 4 – Plan Preparation**
  This section outlines the requirements for plans that implement Low Impact Development for site design and construction. Included in this section are the requirements unique to the preparation of stormwater management plans and calculations as well as discussion of the necessary operation and maintenance documents and instructions to ensure the success of the implementing LID into a proposed development within the City of Ormond Beach.

- **Section 5 –Appendices To This Manual**

This section includes definitions for technical terms associated with Low Impact Development, technical references, and other resources that may assist with the incorporation of Low Impact Development into the design of project sites.

Section 2
Fundamentals and Calculations

Section 2.1: Use of Low Impact Development

This section will serve to introduce the user of this handbook to the use of Low Impact Development. A brief discussion of the principles serving as the basis for the use of LID in site design will be followed by the steps necessary to select and evaluate the effectiveness of integrating IMPs into a site for development or redevelopment. This section will conclude with the methodology used for calculating runoff and storage requirements for sites that elect to incorporate LID into their sites.

Section 2.2: Hydrologic Cycle and Low Impact Development

It is most commonly stated that the primary goal of Low Impact Development is to best mimic the existing site hydrology. One way of evaluating the effectiveness of a system to achieve this goal is to examine the hydrologic budget on a given site. The hydrologic budget is a description of the amount of water flowing in and out of an area along different paths at a given time period. During development, the grading and compaction of a site, construction of buildings, addition of pavement and other impervious surfaces has a direct impact on the hydrologic budget by decreasing rates of infiltration, evaporation, transpiration, and subsurface flow. This cycle is also affected by the reduction of the availability of natural storage and increasing runoff. Figure 2.1a below illustrates the hydrologic cycle and shows the effect of urbanization on this cycle at a specific site.

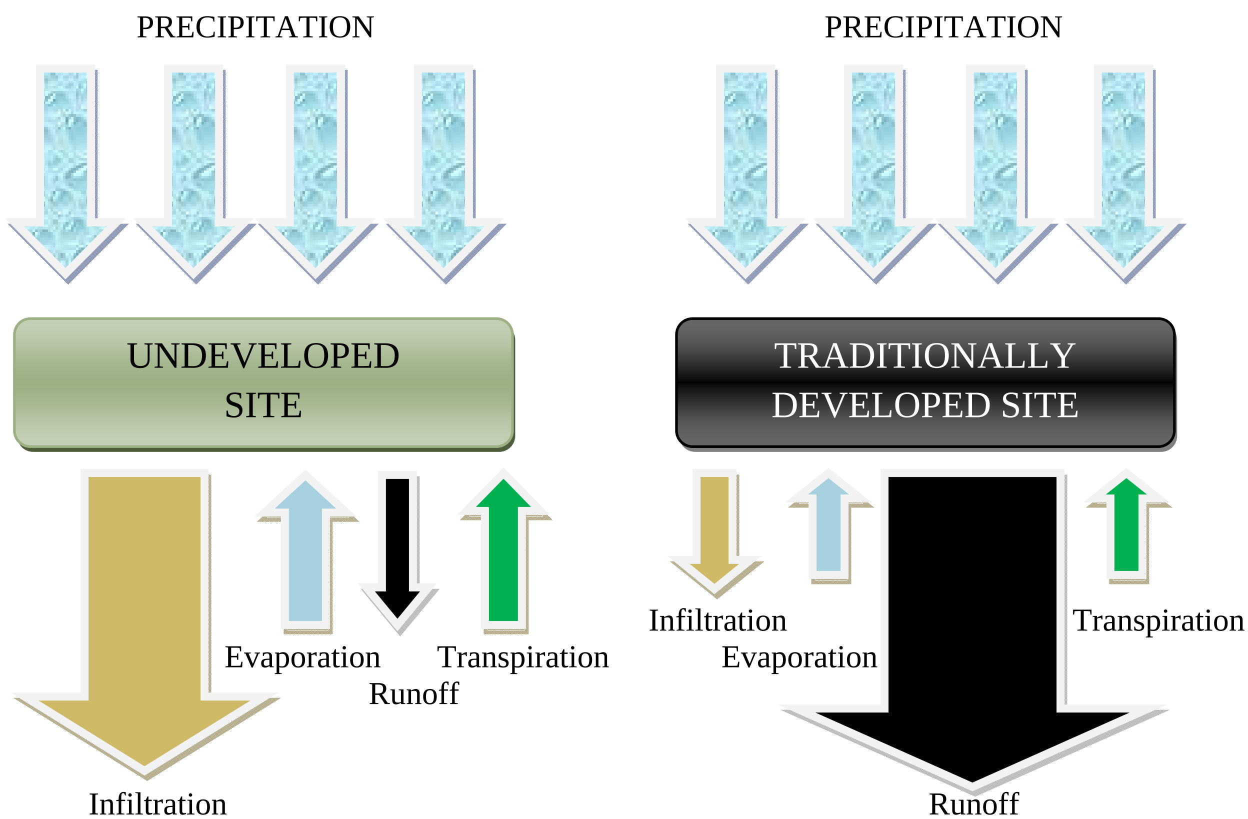


Figure 2.1a: Change to Hydrologic Cycle with Development of Site

The above graphic serves as an exaggeration of what becomes of precipitation once it reaches a site, the following table shows the general magnitude of the effect that increasing the impervious area on a site has on runoff, infiltration, and evaporation / transpiration.

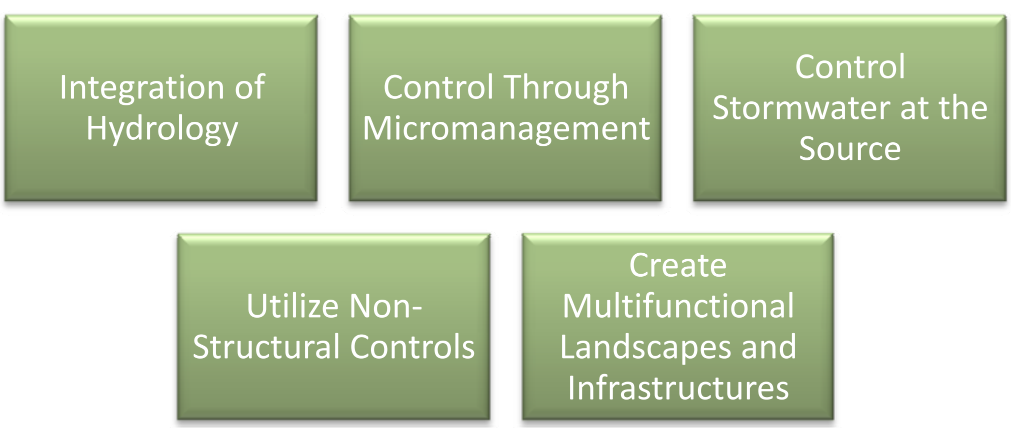
Impervious Surface	Runoff	Infiltration	Evapo-transpiration
0% (Natural Ground)	10%	50%	40%
10% – 20%	20%	45%	35%
35% - 50%	30%	35%	35%
75% - 100%	55%	15%	30%

Section 2.3: Site Planning

While the overall goal of integrating LID in the planning and design of a site is to create a developed site that mimics the hydrology of the property prior to development, there are numerous positive improvements that individually can benefit a site and, in aggregate, can contribute to the overall success found by integrating the practice of LID. These benefits include, but are in no way limited to:

- The Reduction of Impervious Surfaces
- Encouragement of Open Spaces
- Protection of Significant Vegetation
- Reduction of Infrastructure costs
- Reduction in Non-point Source Pollution
- Applicable to Greenfield, Brownfield, and Urban Development
- Non-Stormwater benefits including increased aesthetics, quality of life, water conservation, increased property values.

In their manual, *Low –Impact Development Design Strategies*, Prince George's County Maryland outlined five fundamental concepts common to LID. These concepts, listed below, provide for a simple yet effective guideline for the site planner / engineer to follow when developing a plan successfully integrating LID into a site.



Concept 1- Integration of Hydrology

The traditional approach to stormwater management is to rapidly and efficiently convey runoff and drain the site. LID revises this approach in an attempt to bring the site closer to one that mimics the natural hydrologic function of the water balance effectively reducing off-site runoff and ensure ground water recharge. By introducing the Integrated Management Practices, (IMP), associated with LID to the planning and design of a site, elements are added that assist to store, infiltrate, evaporate and detain runoff. In order to effectively integrate hydrology, and in turn, LID, the planning process should commence with the identification and preservation of hydrologic sensitive areas including flood plains, wetland, water bodies and their buffers, and highly permeable soils. By identifying these areas, the development envelope can be established, allowing for the development of a site that most efficiently maintains the pre-development hydrology of the site in order to get the best yield from the site.

Concept 2- Control Through Micromanagement

A key change in approach from traditional stormwater design to LID use, is the use of micromanagement techniques wherein a change in perspective is employed dividing the site in to multiple smaller sub-basins that are controlled by smaller treatment techniques distributing control and treatment throughout the site. Utilizing control through micromanagement can allow for the use of a greater variety of treatment methods which can make use of the natural site characteristics including infiltration and depressional storage and in doing so, provides for redundancy in treatment and flow control establishing the concept of the "Treatment Train".

Concept 3 –Control Stormwater at the Source

A second benefit of dividing the site into smaller sub-basins is the ability to control stormwater at the source. This concept, which goes hand-in-hand with Concept 2, allows for the design to take advantage of multiple techniques being integrated into the plan that can encourage recharge of groundwater and create a timed discharge from the site more consistent with the naturally occurring hydrology. A key benefit that accompanies this concept can be a reduction in infrastructure costs. With increased distances from the collection point to the treatment measure come increased costs; reducing the distances from the source of runoff, or incorporating control measures at the source can result in the reduction of costs by reducing or eliminating structural conveyance measures.

Concept 4: Utilize Non-Structural Controls

Building upon Concept 3, by relying on simpler more organic means of stormwater control rather than the traditional end of pipe method that has been customary, the site can take advantage of systems that rely on soil, vegetation, gravel rather than concrete and steel. Although traditional treatment methods are needed to be employed in addition to LID IMPs, Integrating them into the site design can create a system that in addition to being more aesthetically appealing, can also by using shallow depths and gentle slopes reduce safety concerns. Employing multiple IMPs may actual provide a technical advantage over a single traditional design in redundancy where one of the control elements can fail without the overall site control failing.

Concept 5: Create Multifunctional Landscapes and Infrastructures
LID is best expressed by this concept, which illustrates the utilitarian nature of the strategy where the landscape elements become multifunctional allowing for detention, retention, filtration and runoff depending on the individual element and its implementation. In LID the landscape / stormwater elements are common to each other making further use of the open space elements and controlling the runoff at the source.

Section 2.3: Site Evaluation and Integrated Management Practice Selection.

When implementing a plan for using LID in the City of Ormond Beach, the steps are grouped into three categories of activities each with its own milestone, and response from the City acknowledging compliance. The three steps of LID are: Planning, Design, and Implementation.

Planning

Successful Low Impact Development begins with a carefully thought out and planned design for the use of LID and the IMPs on a specific site. Because no two sites are the same, and no matter how similar they may seem, no two uses are identical the design phase begins with a carefully executed site assessment. This assessment is critical in order to ensure that the correct IMPs are selected and sized to meet the needs of an individual site. When performing this assessment, it is important for the project team to complete a due diligence of the property, or properties. The first step in the due diligence / planning process is for the project design team to identify jurisdictional regulations affecting the property including zoning requirements that regulate density and geometry of the development, specify technical standards for development, and define hydrologic and resource conservation areas on the project site.

This site analysis continues with a defining of the development envelope. In doing this, the project designer will locate and identify protected areas, setbacks, easements, site topography, existing drainage patterns, soils hydrology, and vegetation. Identification of these features allow for a mapping of the site that allows for the development of a conceptual / preliminary plan for development of the site.

It should be emphasized at this point that although the use of LID in site design can provide many alternatives to traditional site design, it does not relieve the developer from developmental standards within the City of Ormond Beach. Zoning criteria, landscape standards, and traditional site design standards and details are important considerations that should be addressed. With that in mind, an important element of the planning stage is the Pre-Application Meeting with City staff. Because typical conventional regulations for zoning and stormwater control are often inflexible and do not allow development to conform to the natural hydrology of the site, this meeting can allow the developer and design professionals the opportunity to include representatives from the City in the project team. Upon the development of a conceptual plan for the site, the developer can schedule a meeting with staff to discuss the plan and goals for the site. It is at this meeting that City staff can discuss methods of meeting these goals as well as propose alternatives that can assist the project design team create an acceptable path to the ultimate goal of a successfully developed project. This meeting or when necessary series of meetings will initiate the working relationship between the City and Developer for the project. Upon successful completion of the pre-application phase of the project, City staff will provide to the developer a written confirmation outlining the ways that it is understood LID will be integrated into the site design.

Design

Upon completion of the conceptual plan and following a successful pre-application meeting, the design portion of the project begins in earnest. When designing a site with the intention of incorporating LID, the most important factor in the process is the use of drainage hydrology as a defining design element. By using hydrology as the framework for the overall design, the project design team can create a site that maintains the essential hydrologic functions of the site while affording the project to make maximum use of the site. A project can achieve this when hydrologically functional landscape elements, distribution of micromanagement techniques, a minimization of impacts, and the reduction of effective impervious areas are considered in the development of a plan and are being used in order to maintain infiltration capacity, storage, and the longer time of concentration typically associated with undeveloped properties.

In assembling a design for a site employing LID techniques, an iterative effort is often required which takes modifying the design and adjusting the location of IMPs based upon various factor included prevalent soils types, existing drainage patterns, runoff sources, and vegetation. Once the framework for the site has been established, it is up to the project engineer to fully integrate LID minimizing directly connected impervious areas, modifying and increasing drainage flow paths, and completing the comparison between predevelopment and post development hydrology. Examples of techniques that can be employed top accomplish these tasks are shown below:

Minimization of Directly Connected Impervious Areas

- Disconnection of roof drains
- Directing flows to vegetated areas
- Breaking up flow directions from large paved surfaces
- Encouraging sheet flow through vegetated areas.
- Selectively located impervious areas in order to encourage drainage towards natural systems, vegetated buffers, resource areas, or soils with high infiltration ability.

Modifying and Increasing Drainage Flow Paths

- Maximization of overland sheet flow
- Increasing flow paths
- Maximization of the use of open swale systems
- Augmentation of site and lot vegetation.

Once the project design team has completed design for a site, they will submit it to the City for review and to ensure that the LID compliance has been met. In their review, City staff will take into consideration the use of LID IMPs; once the design has been finalized and found acceptable by the City, a development order will be issued approving the plan that notes the use of LID in the project, and the future requirements placed upon the site due to the use of LID.

Implementation

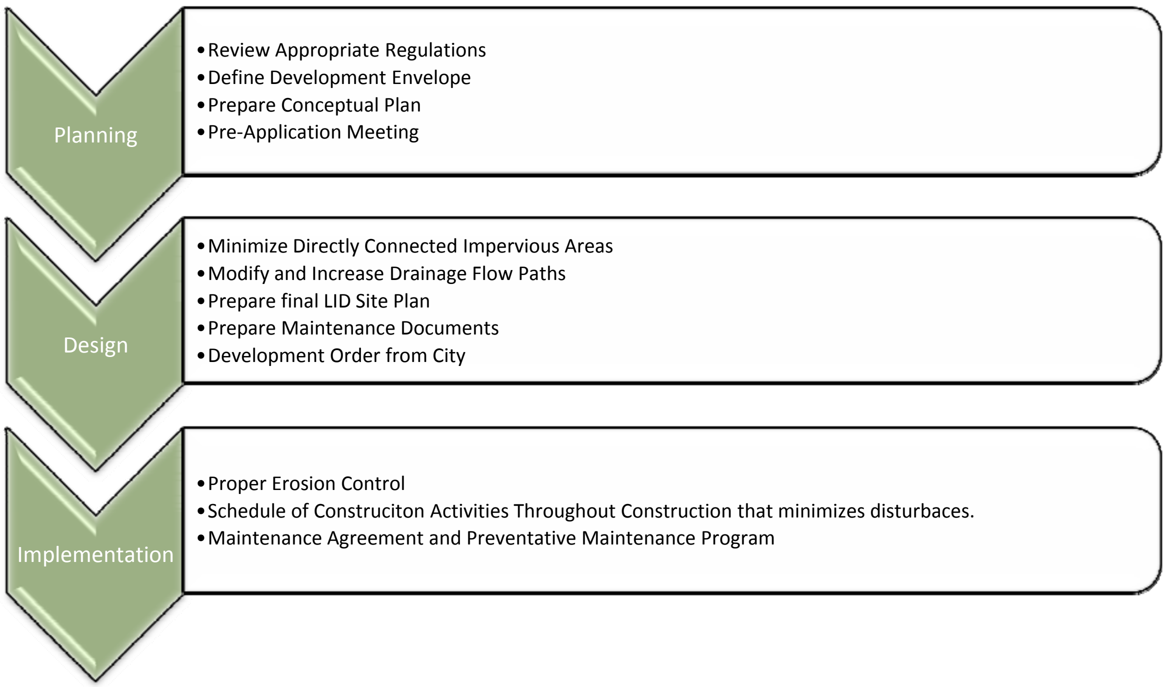
In the use of LID, planning and design are only the beginning in implementing LID within a successful project; equally as important is the implementation of the design. Implementation in itself takes on two important activities, construction of the plan, and maintenance of the system and control devices.

Implementation begins in the planning and design stages in the development of a plan for construction including its phasing and scheduling that considers the site topography, soils, and vegetation. In preparation of this plan, the design professional should take every effort to ensure that soil disturbance and exposure are minimized throughout the process, natural drainage is maintained throughout the process to the greatest extent possible, and that proper devices are implemented to reduce and eliminate erosion and control sediment discharge.

During construction it is important for the contractor and the City to work together to monitor the progress of the project and ensure not only that the proper devices have been installed, but that these devices are maintained throughout the project and replaced when necessary. In all projects, erosion control should be treated as a dynamic element of the construction process; in projects that implement LID this is even more so. It is important for the entire team to identify changing needs of a project and add to or modify the original plan as the project progresses. The second important element of construction is to ensure that the scheduling of operations is respected and thought is used in the clearing and disturbance of the property. Proper scheduling can not only reduce sediment erosion, but reduce compaction of areas intended to provide infiltration. It is important to take an approach of selective clearing and temporary stabilization rather than mass clearing that remains un-stabilized until the project has been finalized.

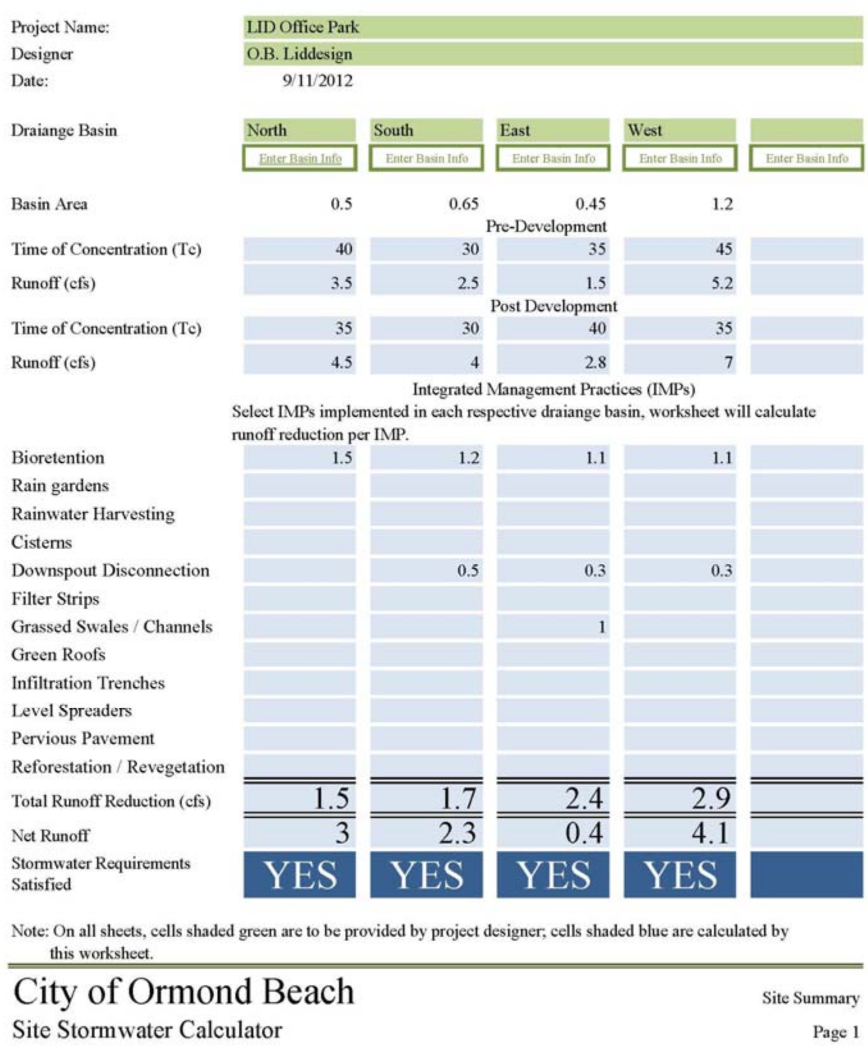
The final element of implementation relates to the operation and maintenance of the site upon final acceptance of the system. The long term success of a site implementing LID requires a plan for inspection and maintenance of the system by a responsible maintenance entity. A maintenance plan should be prepared in the design stage of the project that provides a schedule for inspection of the IMPs included in the system as well as those items required to be performed in a preventative maintenance program. A maintenance agreement establishing the responsible entity for the maintenance system should be recorded at the time of project approval. Standard forms for the maintenance agreement and typical maintenance responsibilities are provided in Appendix ‘B’ of this manual.

The three steps discussed above are summarized in Figure 2.3a below.



Section 2.4: Alternative Stormwater Facility Sizing Calculations

As touched upon in previous sections, the goal of implementing LID IMPs into a site design is the development of a site such that the post development condition mimics the pre-development hydrology for the site. Section Three of this manual summarizes many of the IMP options best suited for use on projects located in the City of Ormond Beach while Section Four provides guidance into the preparation of a LID Plan for a site. In order to evaluate the effectiveness of the LID planned for a site, the project engineer should submit calculations for



Project Name:	LID Office Park				
Designer	O.B. Liddesign				
Date:	9/11/2012				
Draiange Basin	North	South	East	West	
	Enter Basin Info	Enter Basin Info	Enter Basin Info	Enter Basin Info	Enter Basin Info
Basin Area	0.5	0.65	0.45	1.2	
Pre-Development					
Time of Concentration (Tc)	40	30	35	45	
Runoff (cfs)	3.5	2.5	1.5	5.2	
Post Development					
Time of Concentration (Tc)	35	30	40	35	
Runoff (cfs)	4.5	4	2.8	7	
Integrated Management Practices (IMPs) Select IMPs implemented in each respective draiange basin, worksheet will calculate runoff reduction per IMP.					
Bioretention	1.5	1.2	1.1	1.1	
Rain gardens					
Rainwater Harvesting					
Cisterns					
Downspout Disconnection		0.5	0.3	0.3	
Filter Strips					
Grassed Swales / Channels			1		
Green Roofs					
Infiltration Trenches					
Level Spreaders					
Pervious Pavement					
Reforestation / Revegetation					
Total Runoff Reduction (cfs)	1.5	1.7	2.4	2.9	
Net Runoff	3	2.3	0.4	4.1	
Stormwater Requirements Satisfied	YES	YES	YES	YES	

Note: On all sheets, cells shaded green are to be provided by project designer; cells shaded blue are calculated by this worksheet.

City of Ormond Beach
Site Stormwater Calculator

Site Summary
Page 1

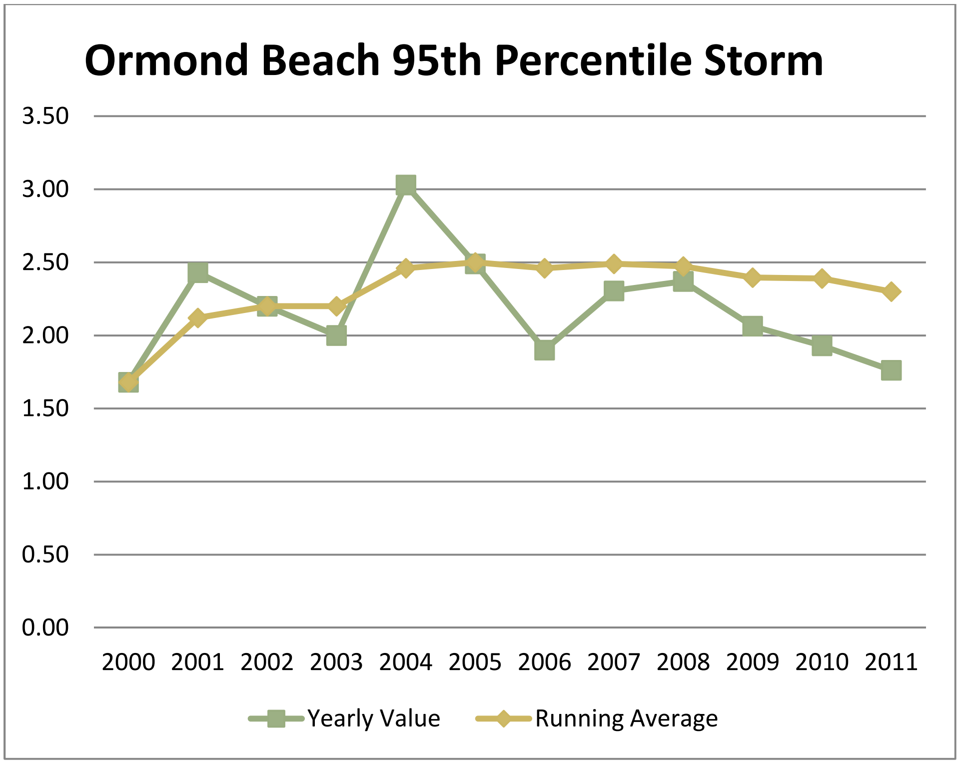
the discharge from the site showing that requirement for net decrease in runoff from the site has been met. In order to assist the project engineer a spreadsheet has been developed and is available for use by the project engineer. This spreadsheet provides for an alternative means of calculation for those site that employ LID in addressing their stormwater concerns; in instances where the project has been designed with LID and the designers seek credit for runoff reduction from their use, the summary sheet from this spreadsheet should be submitted for review with the project design. This single page provides a simplification of the calculations and shows on quick review that requirements have been met.

A copy of the site summary page for an example project is provided at right. This spreadsheet shows at a glance the pre-development and post development runoff from the respective basins on a site as well as the runoff reduction credit provided when individual or multiple IMPs are employed on a site. Based on the rational method for runoff, this spreadsheet calculates the time of concentration and runoff for the onsite sub-basins. One difference that sets this method of calculations apart from those customarily used is that this calculator basis the runoff site and makes its comparison based upon the 95th Percentile rainfall amount for Ormond Beach. Discussion regarding the 95th Percentile rainfall event is covered in Section 2.5 of this manual.

Section 2.5: Establishment of 95th Percentile Rainfall Event

Common practice, specifically within the State of Florida and permitting through its Water Management Districts, has been to design stormwater facilities to control the runoff from significant rainfall events; notably the 25 year – 24 hour rainfall event and the 100 year rainfall event. Theoretically designing for flood control, designing to reduce runoff generated for storms that have the potential of occurring with a four percent (25 Year) storm or one percent (100 year storm) of occurring in any given year. For Ormond Beach, the 25 Year and 100 Year storms are 9 inches in twenty four hours and 11 inches in twenty four hours respectively. There is a movement, closely tied to the use of LID measures in addressing stormwater concerns, which drives stormwater management systems to be designed in order to address those storms likely to occur with regularity for an area. This alternative means of calculating stormwater discharge uses the 95th Percentile storm event as the benchmark upon which to calculate sizing needs. In 2007, Congress passed the Energy Independence and Security Act of 2007(EISA) Section 438 of this legislation established strict regulations for the development and redevelopment of federal projects. This act requires that projects exceeding 5,000 square feet in foot print size maintain or restore the predevelopment rate, flow, and volume of the pre-development hydrology to the maximum extent possible. Executive Order 13514, “Federal Leadership in Environmental, Energy, and Economic Performance” signed by the President on October 5, 2009, set this in motion. Among other options provided for with regards to stormwater runoff, this legislation provides site designers to design, construct, and maintain runoff from all events less than or equal to the 95th Percentile Storm. In this context the 95th Percentile Storm represents the rainfall quantity in a specific event (24 hour period) that ninety five percent of the storms occurring are less than or equal to, essentially all storms other than those outlying two to three rain events that occur each year.

Results of daily rainfall have been obtained from the City of Ormond Beach Utility Department and the 95th Percentile Storm for each year has been calculated. The Table 2.3a shows the results of calculating the 95th Percentile storm from this rainfall data taken at the City of Ormond Beach Wastewater Facility from the year 2000 to present. When calculating a site specific value of this nature it is preferable to base it on as much data as preferable, and in the case of the 95th percentile storm value; sources have indicated that thirty years worth of data should be analyzed, however although it is preferable as shown in this table and the corresponding chart, enough data has been analyzed that the value for this number shows a convergence. It is recommended and planned to re-evaluate this value on an annual basis, making adjustments as may be dictated, **however for purposes of calculating runoff and sizing required IMPs, the value for the 95th Percentile storm should be taken as 2.30 inches.**



Year	95th Percentile Storm (in.)	Running Avg. (in.)
2000	1.68	1.68
2001	2.43	2.12
2002	2.20	2.20
2003	2.00	2.20
2004	3.03	2.46
2005	2.49	2.50
2006	1.90	2.46
2007	2.31	2.49
2008	2.37	2.47
2009	2.06	2.40
2010	1.93	2.39
2011	1.76	2.30

Form the years 2000 through 2011, an average of 87 rainfall events have occurred, calculating runoff and designing the LID stormwater system to meet this (95^{th} percentile value) means that runoff will not occur from sites for 83 (of the 87) events per year.

Section 3
Integrated Management Practices (IMP)

3.0 Introduction to Integrated Management Practices

As discussed in Section 2, key to the successful implementation of LID into a site design is the proper selection of the Integrated Management Practices (IMP). Rather than referring to treatment methods as Best Management Practices (BMPs) which is used more prevalently in conventional development, the treatment techniques used in Low Impact Development are typically referred to as Integrated Management Practices. This term is used in that the techniques are truly integrated throughout the project serving the purpose of storm water management and adding a landscape amenity to the LID design. When developing a LID plan, IMPs are the "tools" the project designer has available that when selected and implemented properly work together to manage storm water runoff from a site.

In their manual, *Low-Impact Development Design Strategies, an Integrated Design Approach*, Prince George County, Maryland outline six steps for IMP selection and design. These six steps are as follows

Step 1: Define hydrologic control required.

This step establishes the sizing requirements for the stormwater management system based upon applicable design parameters specifically these include volume, flow rate, frequency and duration, water quality parameters. These quantifiable values set the size and degree of control based upon the overall project size and scope.

Step 2: Evaluate site constraints.

Hand in hand with Step 1, this step establishes the foundation for the selection and sizing of IMP methods utilized in the LID plan for a site. Physical characteristics that should be considered include property size, shape, slope, soils type(s), water table depth, location of buildings and other impervious surfaces, wetlands and other water features. Although in many regards, these factors can provide challenges to the project designer / engineer to efficiently meet requirements, the basic principles of LID encourage one to mimic predevelopment conditions and integrate controls within the natural environment. It is in this regard that the opportunities of a site are fully defined.

Step 3: Screen for candidate practices.

In this step the project designer takes the knowledge of the site gained in the previous steps, and selects those IMPs that can best be integrated in the site to fully meet the requirements of the proposed development. It should again be stressed that no two sites are identical and that plans utilizing LID cannot simply be taken off the shelf and applied to the project at hand. An understanding of the hydrologic controls and site constraints can allow the designer to select the controls that

Step 4: Evaluate candidate IMPs in various configurations.

Once potential IMPs have been selected the site engineer will work to integrate the controls in the available locations evaluating which arrangement yields meets the control requirements on the site with the highest efficiency and in a manner contributing to the site's aesthetics while considering budgetary constraints.

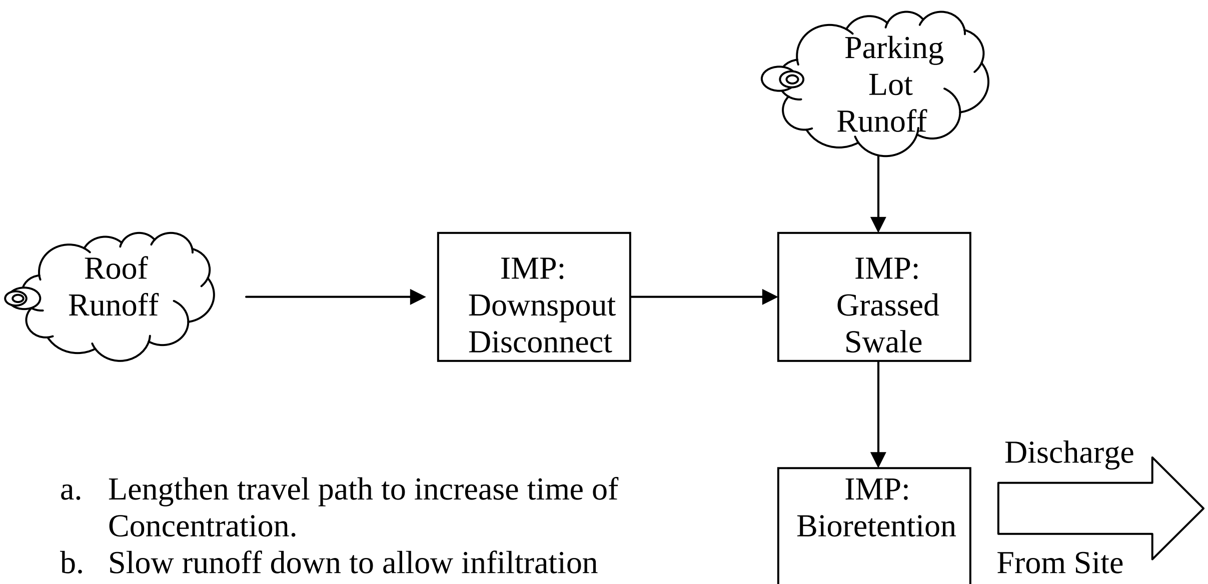
Step 5: Select preferred configuration and design.

The final step in the iterative process, it is here where the final details of the plan are worked out and the ultimate size and configuration of the IMPs are specified.

Step 6: Supplement with conventional controls, if necessary.

Although the project team may begin the process with full intention of designing the site using solely IMPs, there may be times when conventional stormwater treatment methods may be included either due to necessity, or because these techniques are most applicable to the site conditions previously identified. These "bottom of the hill" controls will usually select and sized along with the IMP methods in order to meet the regulatory requirements that must be met by the site.

As discussed above, implementing LID usually requires the arrangement of multiple components that may be IMPs or conventional stormwater techniques to accomplish the management goals of the site. This linking of techniques is commonly referred to as a treatment train. The treatment train effectively is a series of complementary stormwater practices or techniques that when linked together create a system that mimics the pre-development hydrology of the site. IMPs often do not replace the need for typical "bottom of the hill" stormwater management practices and devices such as the traditional wet detention or dry retention facility. What can be gained from the integration of LID techniques however is the creation of a system that is more efficient to the site, adds to the aesthetic of the site, and reduces the burden of downstream properties and waterways? The following schematic drawing shows a typical treatment train for a small office project.



a. Lengthen travel path to increase time of Concentration.
b. Slow runoff down to allow infiltration
c. Retain a portion of runoff on site to decrease volume of runoff.

Figure 3.0.1: Typical Treatment Train Example

The above treatment train example shows the use of three IMPs applied in series to create a treatment system. This system is designed with two objectives in mind, ensuring that runoff meets water quality requirements before its discharge from the project, and more specifically to

LID, aiming to more accurately mimic the pre-development behavior of the site from the perspective of discharge rate and timing.

This remainder of this section is devoted to the introduction of various LID practices that can be incorporated into a plan. For the professional experienced in the use of LID, these IMPs become a virtual "Toolbox" that is virtually unlimited in the use of That being said, it is by no means an all encompassing list; this section, more than any other portion of this guide is intended to be a dynamic document that can be added to as new technologies are introduced and tested. The IMPs provided are those that are best suited for and are most widely applied for use within Ormond Beach. The City always encourages the design community and individual project developers to propose new and innovative practices that can be used with specific plans and throughout the community.

Projects providing creative solutions to the issue of stormwater management are ones that can not only benefit specific properties developed, but could also potentially add to the toolbox of resources available within the City of Ormond Beach.

A number of Integrated Management Practices are well suited for use within the City of Ormond Beach. This section will touch on selected practices that can be integrated into LID plans for sites within the City. These select practices discussed in the remainder of this section are:

- 3.1: Bioretention
- 3.2: Rain gardens
- 3.3: Rainwater Harvesting / Cisterns
- 3.4: Downspout Disconnection
- 3.5: Vegetated Filter Strips
- 3.6: Grassed Swales / Channels
- 3.7: Infiltration Trenches
- 3.8: Level Spreaders
- 3.9: Permeable Pavers / Pervious Pavement
- 3.10: Soil Reforestation / Revegetation

As previously stated with regards to this manual, the above list, and the practices described in the following is by no means a final definitive list of integrated management practices for use within the City of Ormond Beach. Successful implementation of LID requires creativity from all members of the development team, which includes both sides of the table both the developer's and reviewer's. The developer is encouraged to search for tools which although they may be unique, can provide benefits to the specific project and City as a whole. It is anticipated that future revisions of this manual will list additional IMPs, proposed by developers and engineers that can add to the resources of the Ormond Beach Development Community.

3.1 Bioretention

Bioretention is the use of shallow depressional areas that employ conditioned soil and carefully selected variety of plant materials that include trees, shrubs, and other herbaceous vegetation. They are designed to specifically detain stormwater runoff in the engineered soil mix, allowing for t evaporation, transpiration prior to infiltration into the surrounding soils or conveyance through an underdrain system downstream to other treatment techniques and eventual discharge from the site. Bioretention is arguably the most widely studied and promoted IMP, first being widely developed for use by Prince George County, Maryland in the 1990's; this technique may be applied to either commercial development or in a residential situations. Bioretention benefits a site by allowing for a continuation of the pre-development hydrology on a site, and can provide measurable reductions in post-construction runoff rates, volumes, and pollutant loads all while serving as an attractive landscape amenity to a site.

Bioretention for Commercial Applications

Bioretention is well suited to a variety of commercial applications; tree wells and shrub pits can be incorporated in tight locations or into sidewalk plans, linear bioretention area features can be incorporated into roadways wither in the median or outside the shoulders, and islands designed into a parking lot can be designed as bioretention either as a stand-alone treatment practice or as an element in the treatment train serving a site. When incorporating bioretention into a site, as with any LID IMP, a change of design approach is required on the part of the project design professional to incorporate the IMP into the site. In the case of parking lot bioretention areas, traditional elements such as curbs, inlets and culverts are replaced by depressed islands, flush grades, and level spreaders. This section will touch on the elements needed to evaluate the applicability of incorporating bioretention into a site as well as the planning, selection, and sizing of the key elements required with bioretention.

When utilized in residential development, smaller depressional areas where the catchment areas is a single lot, or parts of multiple lots the bioretention cell is often referred to as rain garden. In commercial applications, the bioretention basins or cells are typically integrated into the treatment train for the overall system in a manner that allow for the site to be divided into drainage basins that drain into basins that are sized and spaced to provide the required treatment and storage while contributing to the aesthetics of the site. This section will deal primarily with the use of Bioretention in non-residential applications; Section 3.2 will address rain gardens, the application of bioretention in residential development. Because the relationship is so close between these two sections, certain elements detailed in this section will apply to rain gardens, and certain elements related to bioretention in general will be covered in Section 3.2.

Planning and Design

Bioretention is a very adaptive treatment method that can be used to manage stormwater runoff on a wide variety of sites in a number of environments including residential, commercial, and institutional developments and can be found in urban, suburban, and rural areas. Best suited for small impervious or disturbed pervious areas some of the criteria that should be kept in mind when selecting a site and planning the design of a biorention area. These planning criteria are summarized below.

- Contributing Basin — With optimal native soils and in an ideal situation, contiguous bioretention areas can be designed that handle the runoff from basins that can be as large as five acres in size. Ideally however, basins contributing to runoff to a bioretention area should be greater than 2,500 square feet and less than two acres in area. Larger basins should be managed by multiple bioretention facilities.
- Facility Size — As a rule of thumb, for planning purposes, bioretention areas can generally be expected to be five to ten percent of the size of the contributing basin.
- Soils — Bioretention areas can generally be designed without underdrains when native soils have infiltration rates of 0.5 inches per hour or greater, when infiltration rates do not exceed 0.5 inches per hour underdrains should be incorporated into the design.
- High Water Table — Sufficient depth should be planned for the planting / volume storage bed, with this in mind, a minimum depth of four feet is recommended from the bottom of the bioretention area to the seasonal high groundwater level or restrictive soils. This depth can be reduced to two feet however additional elements may need to be incorporated into design to avoid reduction in the performance of this IMP.
- Distance to Features — To prevent damage to building foundations and contamination of groundwater, a water proof liner should be incorporated into design unless the following dimensions can be maintained: 10 feet to building foundations, 10 feet to property lines, 100 feet to private water supply wells, 100 to septic systems, 100 feet to surface waters.
- Recovery Time — The system should recover the volume of the critical storm within a period of time not exceeding 72 hours.
- Critical / Design Storm — As with the design of other Integrated Management Practices, bioretention facilities should be designed to with respect to the 95^{th} percentile storm as discussed and detailed in Section 2.5 of the Low Impact Design Manual for the City of Ormond Beach.

Components of Bioretention

A bioretention area can be broken into a number of component elements, these elements are noted in Figure 3.1a which shows, schematically a sectional view typical of a bioretention facility. These components are further described as follows.

Bioretention Component 'A' - Pre-Treatment Area

An optional component to bioretention it is recommended to incorporate this into design, especially in areas where a significant volume of suspended material or debris is anticipated such as parking lots and other commercial areas. Pre-Treatment may occur through use of vegetated buffer strips, stabilized inlets, sediment traps, or a simple grass buffer strip. Elements should be incorporated that limit inlet velocities and reduce the tendency of erosion.

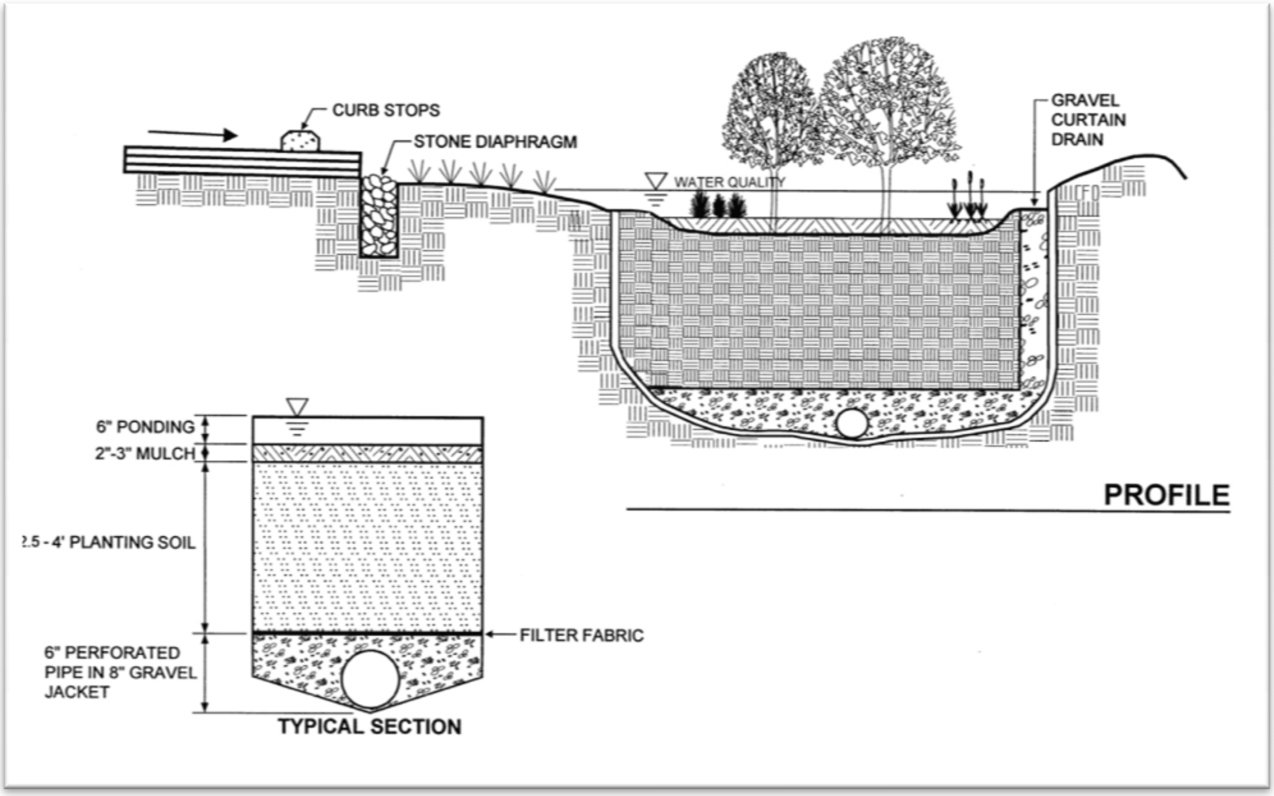


Figure 3.1a: Bioretention Area Sectional View

Bioretention Component 'B' – Ponding Area

This area provides temporary surface storage of runoff allowing sediment to settle and the physical operations of evaporation, transpiration, and infiltration involved to occur. Depths should be limited to between six and twelve inches, to ensure a proper functioning of the IMP, and to maintain safety and aesthetics of design. Ponded water should recover in less than 72 hours.

Bioretention Component 'C' – Organic Mulch Layer

As a top layer, bioretention areas should provide a layer of organic mulch on the bottom of the practice. This layer should be approximately two - three inches deep and cover the surface of the basin bottom to the expected high water line; avoid allowing the mulch depth to exceed four inches as the soil aeration may experience a reduction. The mulch selected preferably should consist of either shredded hardwood mulch, or when possible, compost or leaf mulch. Avoid using pine bark mulch or pine straw as these materials do not readily compost. This component provides a first layer of filtration for runoff pollutants, and also serves the bioretention area by stabilizing the underlying soil reducing erosion and maintaining soil moisture. The mulch also serves a cultivator for biological activities, allows for the decomposition of organic material and promotes the adsorption of heavy metals.

Bioretention Component 'D' – Plant Material
Proper plant material selection for use in a bioretention area is an important element in the design process when creating an LID plan for a site and detailing the bioretention area employed. The design professional should select and specify native plant species that can be installed in the practice that can tolerate periods of drought and inundation.
Plant material is the key element in the transpiration process and allows for the absorption of stormwater directed to the bioretention area. The root system of the plant material also plays multiple roles within the process occurring in the bioretention area. The development of a healthy root system creates pathways for infiltration of runoff, while an established root system reinforces long term performance of the subsurface infiltration. Finally the root system can serve as a host for bacteria communities further establishing healthy soil and promoting the water quality benefits desired by the practice.

Depending on the individual plan and location for a bioretention facility, the proper selection of plant material can also play a key role in not only the future aesthetics of the site, but can also aid in the establishment serve of habitats for animal and insect communities. Section 3.2: Rain Gardens provides a list of recommended plant material for use in bioretention facilities proposed in Ormond Beach. Timing of the planting of materials may vary depending on the plant selection but as a guide, trees and shrubs should be planted from mid-April to early June or mid-September to mid-November. Planting dates may vary based upon rainfall / drought conditions with extended periods permitted during period where a regular water source is available, and a shortening of the planting period in years of drought.

Bioretention Component 'E' – Planting Soil / Volume Storage Bed.
Below the Organic Mulch Layer lies the Planting Soil which serves the bioretention area by providing water and nutrients to the plant material included as Component 'D'. This layer enhances biological activity, enhances root growth, adsorbs nutrients, and importantly provides for storage of stormwater within the voids of the soil particles included in this layer. The clay content of the soil in this layer should be very low, and consist of a well mixed blend of topsoil, compost, and sand.

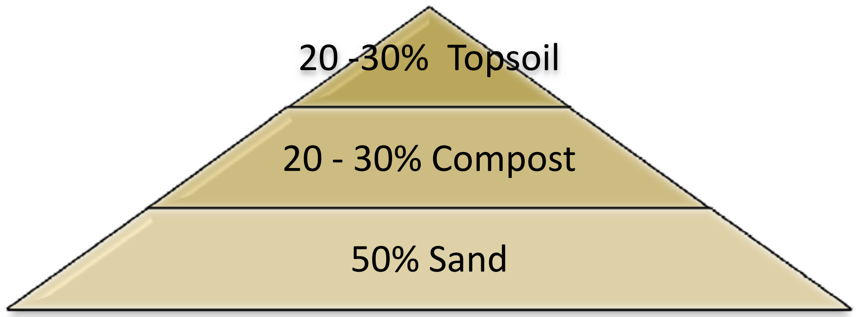


Figure 3.1b: Soil Mix Profile for Bioretention and Rain Gardens

It is recommended, in order to take maximum advantage of the storage capabilities of this layer that the bottom of this layer should be fully above the water with a minimum overall depth of two to three feet. In some cases in may be advantageous to include a subsurface storage/infiltration bed; when used ensure that it consists of a base of clean gravel six inches thick with significant void space. The entire infiltration bed should be enveloped in engineered filter fabric (geotextile).

Bioretention Component 'F' – Recovery and Discharge
A final component that is an important contributor to the success of the bioretention system is the condition of recovery. The recovery of the system is greatly dependent on the in-situ or native soils; for optimal performance, the soil should exhibit an infiltration rate of greater than or equal to 0.5 inches per hour. In cases where infiltration is less than 0.5 inches per hour, incorporation of an underdrain is required with the plan to ensure that the system meets the requirement of recovery within seventy two hours. Typically the designer should design the underdrain system of small diameter (six to twelve inch) perforated pipes in a clean gravel trench wrapped in geotextile. Where underdrains are included, they should be connected in series to additional IMP methods to complete the treatment train. As with any stormwater pipe element, a method of cleaning and inspecting the pipes should be included in the design.

In each of these components, accommodations for the larger storm events should be considered. In addition to percolation, accommodation should be made in the bioretention system to allow for positive overflow. This allows for runoff to bypass the bioretention area under large storm event conditions or when the surface or subsurface storage capacity is exceeded. This overflow can be an achieved by means of inlets, weirs, and risers or other types of diversion structures connected to an underdrain system.

Sizing and Placement
The initial sizing of a bioretention area begins with the infiltration testing of the native soils at the proposed location of the bioretention facility. The results of the infiltration testing will enable the design professional to determine if bioretention is possible on the site and, based upon infiltration rates and restrictive layers, the necessity of underdrains. Once this evaluation has been complete, the sizing of the bioretention area becomes a two step process Initial Sizing and Verification of that volume reductions are being met. The initial sizing of a bioretention facility

and its dimensions should be calculated using Darcy's Law to provide sufficient storage to reduce runoff from the 95th Percentile Storm; see Section 2.5 for establishment of 95th Percentile Storm for Ormond Beach. This equation varies depending on the inclusion of underdrains in the system and is as follows:

Bioretention with Underdrains:

$$\boldsymbol{A_{bio}} = (\boldsymbol{RR_v})(\boldsymbol{d_{bio}}) \div [(\boldsymbol{k_{bio}})(\boldsymbol{h_{bio}} + \boldsymbol{d_{bio}})(\boldsymbol{t_{drain}})] \qquad \text{Equation 3.1a}$$

Where:

$\boldsymbol{A_{bio}}$ = surface area of bioretention area (ft^2)

$\boldsymbol{RR_v}$ = stormwater runoff volume generated by target runoff reduction rainfall event (ft^3) – 95th percentile rainfall event

$\boldsymbol{d_{bio}}$= depth of the bioretention area planting bed (ft); for initial calculations use 36 inches (or more), unless a shallow water table is found on the development site.

$\boldsymbol{k_{bio}}$ = coefficient of permeability of bioretention area planting bed (ft/day); use 0.5 ft/day for the engineered soil mix specified above

$\boldsymbol{h_{bio}}$ = average height of ponded water above bioretention area (ft); use 50% of maximum ponding depth

$\boldsymbol{t_{drain}}$=design bioretention time (days); although the requirement calls for the recovery of the system in 72 hours or less, it is recommended that for preliminary sizing design a shorter period of time is utilized in order to incorporate a safety factor.

Where infiltration rates do not require the inclusion of underdrains in the design of the bioretention system, the following modification of Darcy's Law can be used to calculations the dimensions of the bioretention system.

$$\boldsymbol{A_{bio}} = (\boldsymbol{RR_v})(\boldsymbol{d_{bio}}) \div [(\boldsymbol{i_{soil}})(\boldsymbol{h_{bio}} + \boldsymbol{d_{bio}})(\boldsymbol{t_{drain}})] \qquad \text{Equation 3.1b}$$

In this equation all values are the same as in equation 3.1a other than the replacement of $\boldsymbol{k_{bio}}$ with $\boldsymbol{i_{soil}}$; in this equation,

$\boldsymbol{i_{soil}}$ = infiltration rate of underlying native soils (ft/day) or coefficient of permeability of bioretention area planting bed (ft/day), or use $\boldsymbol{k_{bio}}$ = 0.5 ft/day for the engineered soil mix specified above, whichever is less.

For non-underdrained systems, the runoff volume can be considered removed , for systems including underdrains, the bioretention cell should be considered a detention device that allows the calculated volume to discharge to surface water over time $\boldsymbol{t_{drain}}$.

Verification that the volume reduction occurs can be calculated by looking at the three volume components: surface storage volume, soil storage volume, and infiltration bed volume. The calculations for this volume are given by the following series of equations:

$$V_{bio} = V_{surface} + V_{soil} + V_{sub}$$ Equation 3.1c

Where;

V_{bio} = Total Bioretention Volume (ft^3)

$V_{surface}$ = Surface Storage Volume (ft^3)
= Average Bed Area (ft^2) x Maximum Design Depth (ft)

V_{soil} = Soil Storage Volume (ft^3)
= Infiltration Area (ft^3) x Depth of Amended Soil (ft) x Void Ratio of Amended Soil

V_{sub} = Subsurface storage/Infiltration bed Volume (ft^3)
= Infiltration Area (ft^3) x Depth of underdrain material (ft) x Void Ratio of storage material

High Water Table Option

When confronted with a site with a high water table, an option proposed in Sarasota County's LID Manual is a possibility. This option allows for implementing bioretention in areas where a high seasonal high water level is present and sufficient separation is not attainable. This option shown in Figure 3.1c separates the planting soil layer into two layers, a planting soil filter bed and a nutrient adsorption layer.

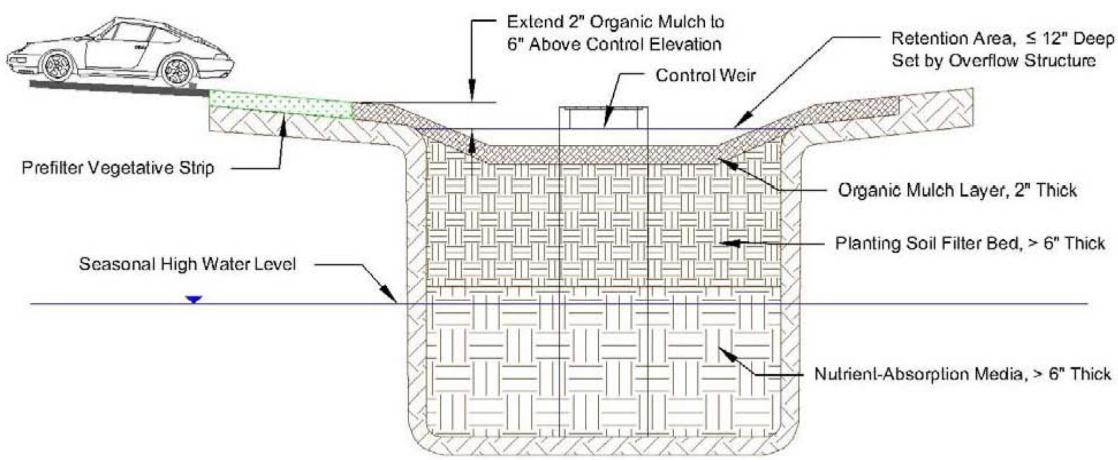


Figure 3.1c: Shallow Bioretention Area

In this scheme for a shallow bioretention area, the planting soil bed a minimum of six inches below the season high water level with the nutrient adsorption layer filled to just above the season high. The remainder of the excavated areas is then backfilled as the planting soil filter bed, this area should be a minimum of six inches thick. Properties of the soils found in each layer are given below.

Comparison of Soils Planting Soil Filter Bed / Nutrient Adsorption Media

Planting Soil Filter Bed

- Layer should be at least six inches thick,
- Bed material should be sandy loam, loamy sand, or loam texture,
- Clay content should be between 3% and 5%,
- Soil pH should be between 5.5 and 6.5,
- Organic matter content should be between 3% and 10% by volume,
  Carbon to nitrogen ratio of at least 50%.

Nutrient Adsorption Layer

- Layer should be at least six inches thick,,
- Unit weight should be greater than 80 pounds per cubic foot when dry,
- Greater than 15% but less than 30% of the particles passing the #200 sieve,
- The media water holding capacity should be at least 35% as measured by porosity,
- At the specified unit weight noted above the vertical permeability must be at least 0.03inches per hour but less than 0.25 inches per hour,
- The media must have an organic content of at least 5% by volume. This organic content should be in the form of hardwood chips evenly distributed throughout the layer,
- The media pH should be between 6.5 and 8.0,
- The concentration of the soluble salts should be less than 3.5 g (KCl)/L,
- The sorption capacity if the sand should exceed 0.005 mg OP/mg media,
- The residual moisture content should exceed 50% of the porosity.

Construction Guidelines

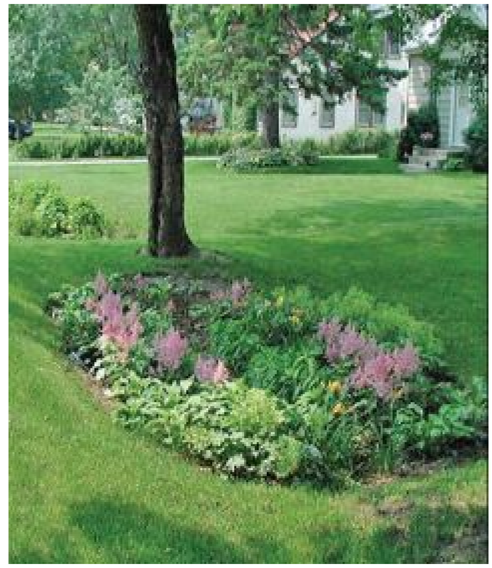
To ensure that a bioretention system functions as planned upon completion of site development, it is important to follow certain guidelines when constructing a bioretention cell and working around a bioretention cell on a site. The following steps are ones which should be followed in addition to the minimum construction guidelines and erosion control measures set forth by the standard notes and details of the City of Ormond Beach.

1. Complete site grading, minimizing impact and compaction at the location of the proposed bioretention cell(s). All inflow conveyance measures should be completed (curb cuts, flumes, etc.) as well as pre-treatment devices such as filter strips, swales, etc. Protection should be installed to prevent drainage and sediment to entering the area of the bioretention construction.
2. Prepare the Subgrade
    a. Avoid compaction or excessive construction traffic in the bioretention area footprint.
    b. Initial excavation of the bioretention cell can be performed during site rough grading but should not occur closer than one foot from the final bottom elevation. Final excavation should not occur until all areas in the drainage basin have been stabilized.

   c. Scarify underlying soils to a minimum depth of six inches in areas erosion of subgrade has caused accumulation of fine particles and areas of surface ponding in the bottom of the bioretention area.
   d. Finalize excavation to design line, and grade. Fill and lightly re-grade any erosion damaged areas. Level the bottom of all bioretention areas.
3. Stabilize grading of the basin except for the footprint area of the bioretention cell.
4. Installation of Bioretention
   a. Excavate bioretention area to proposed invert depth and scarify existing soil surfaces. Do not compact soils.
   b. Notify the engineer of record to inspect the condition of the subgrade. prior to installation of bioretention upon completion of subgrade preparation.
   c. Install subsurface storage/infiltration bed as well as underdrain system if called for in design.
   d. Backfill bioretention area with amended soil as shown on plans and specification, it is recommended that the amended soil by overfilled to allow for settling, place amended soils in lifts not exceeding 18 inches in depth lightly compacting by means of light hand tamping. Do not over compact, keeping equipment movement over the soil to a minimum.
   e. Complete final grading to achieve proposed design elevations, allow tolerance for mulch layer and / or topsoil as specified on plans.
   f. Presoak the planting soil at least 24 hours prior to planting of vegetation.
   g. Plant trees and shrubs.
   h. Install two-three inches of shredded hardwood mulch or compost evenly as shown on the plans.
   i. Install sediment control devices to protect bioretention area during remainder of construction period and while vegetation is being established.
   j. Upon full establishment of vegetation, notify project designer for to inspect bioretention area. Upon satisfactory review, remove sediment control devices.
5. Mulch and install additional erosion controls as necessary.

As with all IMPs, proper functioning is reliant upon the treatment facility being properly constructed and properly maintained. Additional details for construction and maintenance and inspection forms are provided as an appendix to this manual.

3.2 Rain Gardens



As discussed in Section 3.1, bioretention can be an effective way of implementing LID principles into a development. When applied to residential conditions, the IMPs that provide bioretention for a site are referred to as rain gardens. Rain gardens can prove to be an attractive alternative to traditional stormwater in residential developed properties. As with bioretention used in commercial applications, the use of bioretention in the form of a rain garden in a residential application can provide the treatment required for a site by trapping and removing suspended solids and absorbing pollutants into the plants and soil included in the rain garden; at the same time, volume reduction is achieved through the storage provided and percolation of water into the soil. Rain gardens also provide the additional benefit to the homeowner of water conservation in that rain gardens typically do not require irrigation once established. Care should be taken in sizing the rain garden, placement of the rain garden on the site, and selection of plants for use within the rain garden.

The most critical decision in employing a rain garden for use on a residential property is location and placement on the lot. Rain gardens should be located such that 100% of the runoff from the property, both impervious and pervious areas of the rain garden. Rain gardens can be placed in close proximity to the house, or at a more considerable distance from the house. Some important factors that should be considered when specifying rain garden locations on a lot include:

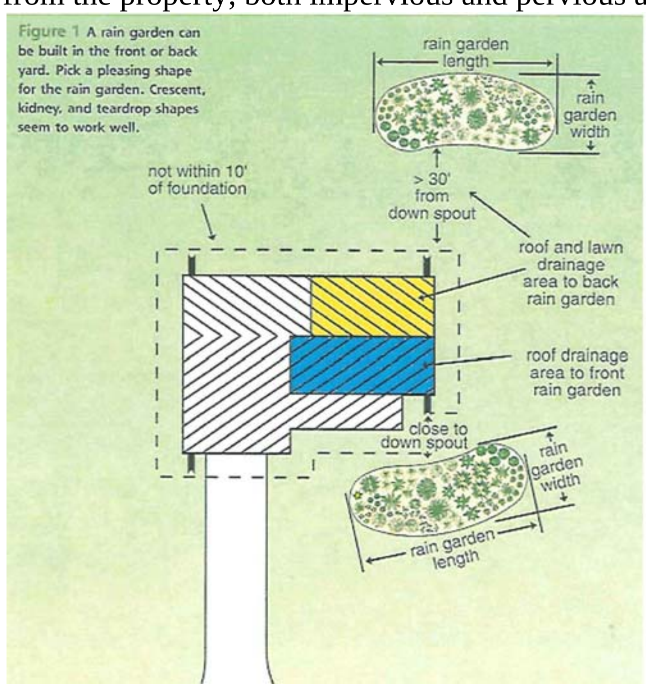


Figure 3.2a: General Location Considerations of Rain Gardens

- Ensure that the rain garden is properly sized
- Do not place rain gardens closer than ten feet to the building.
- Locate rain gardens in natural low spots, if possible.
- Place rain gardens in locations that allow for drainage to easily travel to rain garden as well as allowing for overflow of runoff downstream during periods of extreme rainfall.
- Avoid creating trip hazards and impeding the functional use of the property

Once the location for the rain garden has been identified, the design of the rain garden should be considered. When designing a rain garden, one should consider size, shape, soil, and plant selection. When sizing a rain garden, the critical dimension to ensure ongoing functionality is the depth of the rain garden. Although the depth can vary from system to system (including those on the same site), rain gardens should ideally remain 6” – 8” in depth and under no circumstance should they exceed 12” in depth in order to ensure that water does not pond for periods of time greater than 24 hours in order to reduce the incidence of mosquito breeding and reduce safety hazards.   Rain gardens should be sized such that they are capable of storing 1” of runoff from the basin area; the surface area of the rain garden this translates to a basin that is approximately 10% of the basin area. While not affecting the functionality of the rain garden, shape of the garden basin is another important factor. Largely a matter of preference, rain gardens can be laid out with straight banks and geometric angles, however freeform, “natural” shapes are generally preferred and provide an aesthetic to the rain garden that works well with the plant selection.

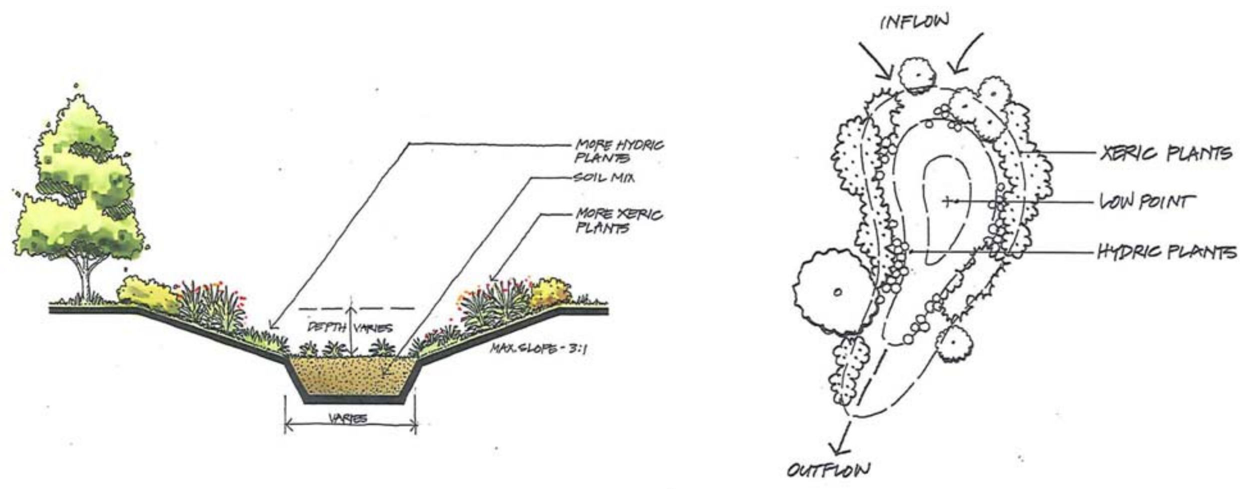


Figure 3.2b: Common Rain Garden Details

Proper soils are an important factor in the successful functioning of rain gardens as well as all implementations of bioretention. The bottom of the rain garden should be over excavated and the soil replaced with a thoroughly blended mix of sand (50%), topsoil (20%-30%) and compost (20%-30%) as previously shown in section 3.1 Bioretention.

Lastly, plant selection is critical to the functioning and aesthetic of a successful rain garden. Native plants should be selected that meet the preferences of the homeowner with more Xeric species (drought resistant) being placed towards to outer limits of the rain garden, and more hydric (water resistant) plants place interior to the rain garden, nearer the basin low point. Selection should consider variety and compatibility, a compiled list of plants that have proven to work well in Florida rain gardens is provided in the lists that follow.

Rain Garden / Bioretention Plant Selection List

Wildflowers, Ferns, Grasses, and Sedges:

- *Asclepias incarnata,* Swamp Milkweed
- *Canna flaccida,* Golden canna
- *Pontederia cordata,* Pickerel Weed
- *Eupatorium coelestinum,* Blue mistflower
- *Helenium pinnatifidum*, Everglades daisy
- *Lobelia glandulosa*, Glades lobelia
- *Sabatia* spp., Marsh pinks
- *Acrostichum danaefolium,* Leather fern
- *Osmunda regalis* var. *spectabilis,* Royal fern
- *Thelypteris palustris,* Marsh fern
- *Woodwardia virginica,* Virginia chain fern
- *Muhlenbergia capillaris,* Gulf muhly grass
- *Aster carolinianus,* Climbing aster
- *Asclepias tuberosa*, Butterfly weed
- *Iris virginica*, Blue flag iris
- *Coreopsis lanceolata*, Tickseed
- *Spartina bakeri,* Cordgrass
- *Muhlenbergia capillaries*, Muhly grass
- *Osmunda cinnamomea*, Cinnamon Fern
- *Chasmanthium latifolium*, River Oats
- *Osmunda regalis*, Royal Fern
- *Hibiscus coccineus*, Scarlet Hibiscus
- *Rudbeckia hirta*, Rudbeckia
- *Veronia gigantea*, Ironweed
- *Solidago sp.*, Goldenrod

Trees and Shrubs:

- *Acer rubrum* var. *trilobum*, Red maple
- *Annona glabra,* Pond apple
- *Betula nigra,* River birch
- *Cephalanthus occidentalis,* buttonbush
- *Chrysobalanus icaco,* Cocoplum
- *Gordonia lasianthus,* Loblolly bay
- *Hibiscus grandiflorus* Swamp Hibiscus
- *Ilex cassine*, Dahoon holly
- *Ilex glabra*, Galberry
- *Ilex vomitoria,* Yaupon Holly
- *Itea virginica*, Virginia Willow
- *Magnolia virginiana,* Sweetbay magnolia
- *Myrica cerifera,* Wax myrtle
- *Myrsine floridana,* Myrsine
- *Nyssa sylatica*, Black gum
- *Pinus palustris,* Longleaf pine
- *Sabal palmetto*, Cabbage palm
- *Sabal minor,* Dwarf palmetto
- *Salix caroliniana*, Coastal plain willow
- *Sambucus canadensis,* American elderberry
- *Serenoa repens,* Saw palmetto
- *Styrax americana*, snowbell
- *Taxodium ascendens*, Pond cypress
- *Taxodium distichum,* Bald cypress
- *Viburnum obovatum*, Walter’s Viburnum

Section 3.3 Rainwater Harvesting / Cisterns

One IMP that is tied closely to water conservation is rainwater harvesting. Low in cost, and typically sized to store a pre-determined volume of runoff, rain barrels (small scale) and cisterns (large scale) captured the runoff from building downspouts and store it for release at a controlled rate. The release of water can either be used for irrigation of site landscaping, for infiltration into the soil or in some instances, cisterns that can store adequate volumes can be incorporated into "gray water " systems for homes or commercial buildings providing water for the flushing of toilets or other like applications.

Figure 3.3a: Rain Barrel

Cisterns and rain barrels are found in a variety of sizes ranging from 40 gallon rain barrels to cisterns that can store volumes in excess of 1,000 gallons; these devices can be incorporated the aesthetics of a site through architectural measures, or by incorporation into the landscape plan for a site.

Certain design considerations should be accounted for when employing rainwater harvesting measures, these include:

- Sizing and selection of the rainwater harvesting devices based upon intended use and roof runoff area to be directed to the container.
- Prevention of mosquito breeding.
- Proper filtration to prevent clogging from leaves and other debris.
- Valves and controls to direct water as dictated by use.
- Direction of overflow in instances of storm events that exceed capacity of rain barrel or cistern.
- Accommodation of maintenance.

Figure 3.3b: Above Grade Cistern

Closely related to rainwater harvesting, Cisterns are essentially large scale rain barrels that area available in a variety of sizes and styles. Traditionally underground storage, many above ground options have become available in recent years that can be both utilitarian and function as an architectural element. These tanks collect runoff from connected downs pouts and provide retention volume storage; the stored water can then be reused for irrigation and/or other gray water uses. The size of cisterns is greatly affected by the size of the roof area directed to the storage system, given the impervious nature of roof tops, large volume cisterns may be required to fully take advantage of the benefits that cisterns may provide. Typically, a good rule of thumb for cistern storage is provided in the following equation:

$$(A) \times (R) \times (600 \text{ gallons}) / 1000 = (G)$$

Where: A = (catchment area of building)
R = (inches of rain)
G = (total amount of collected rainwater

Simply stated, 1" of rainfall on a 1,000 square foot roof, would provide 600 gallons of rain water that will be available for use. In Ormond Beach, where annual rainfall totals exceed 50 inches per year, a moderate sized commercial building of 5,000 s.f. could yield 150,000 gallons of reuse water per year.

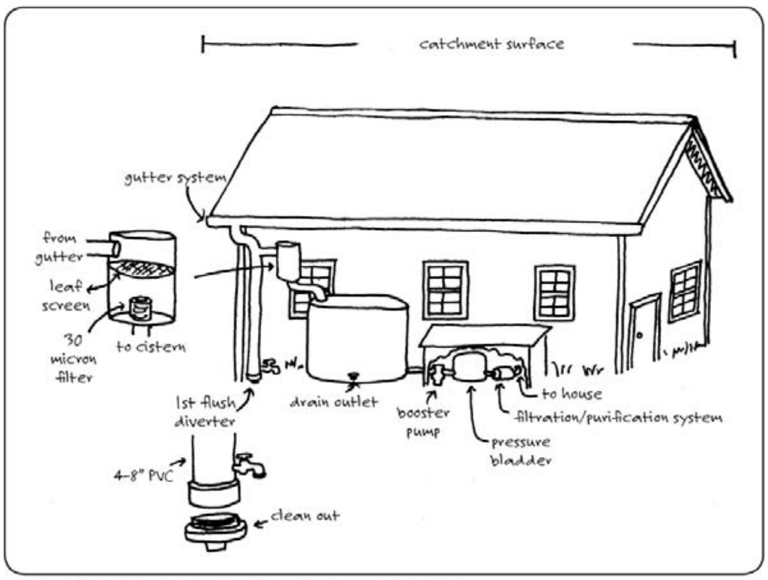


FIG. 8.2. **Typical components of a whole-house rainwater harvesting system.**

Figure 3.3c: Schematic View of Rainwater Harvesting System

Section 3.4 Downspout Disconnect

A fundamental element to most IMPs, disconnect of runoff from the source to the receiving body allows for the integration of other practices. Specific to this section, the disconnect of roof runoff can allow for the reduction of discahrge peak rate and volume by directing flow to other IMPs. By creating opportunities in the design of a site, typically providing landscaped areas or other pervious surfaces adjacent to buildings, this simple element can help spread flow encouraging infiltration and result in measurable reductions in stormwater runof rates, volumes, and pollutant loads.

Reduction in peak flows can also be achieved by directing runoff from other impervious areas to vegetated surfaces. Directing runoff from driveways and parking lots towards spillways that outfall to vegetated swales or bioretention basins rather than directing flow to catch basins connected to underground culverts. This technique can aid by breaking up flows, encouraging sheet flow through vegetated areas, and incrase infiltration and the time of oncentration of runoff prior to discharge to final treatment elements or from the site.

When integrating disconnection into an LID Plan for a site, certain considerations should be made:

- Limit the contributing impervious area to each downspout or impervious area discharge point, typically consider a pervious receiving area twice the area of the contributing source.
- Allow sufficient flow path across pervious element to encourage infiltration and take advantage of ability to increase concentration time.
- Provide for sufficient Width to Length Ratio to allow for spreading across element.
- Limit flow length of impervious surface discharging to prevent increased velocities and the possible chanelization of runoff and erosion.
- Keep Slopes of pervious surface minimal.
- Be aware of hydrologic soils groups for the location where the downspout is directed; runoff reduction is generally fairly predictable in Type ‘A’ and ‘B’ soils, however in Type ‘C’ and ‘D’ soils, alternmative runoff reduction techniques may need to be employed such as ammending soil, rainwater harvesting, aeration of soil.

An element that should find its way into any LID Plan to a lesser or greater degree, Disconnection can benefit a site in many reagrds, most notably its ability to drive the site towards a hydrology closer to pre-development condition.; benefit can also be measured in the cost savings that can result in lesser infrastructure costs, as well as increased pollutant removal efficiencies.

Design Factors

When considering, and including disconnection in an LID plan, certain design factors should be considered. Some factors that should be considered in the design of a site and the recommended limits of these parameters are provided in the table that follows:

Design Factor	Recommended Parameter Limits
Maximum Impervious (Rooftop) Area Treated per disconnect	1,000 square feet per disconnect
Longest Flowpath	75 Feet
Disconnection Length	Equal to the longest flow path (minimum recommende = 40 feet
Disconnection Slope	1% - 2%
Distance to Extend From Buildings or Foundations	Extend downspouts 5 feet away from building.

Included with the appendix to this manual is a recommended maintenance schedule and inspection form for sites utilizing downspout disconnection,

3.5 Vegetated Filter Strips

A vegetated filter strip, or filter strip, is a band of uniformly graded, densly vegetated ground planted between a pollution source and downstream water bodies, conveyance devices, or IMPs; the typical vegetation for this technique is turf grass. Turf grass must be grown in a sandy material to be used for this purpose. Filter Strips typically function by slowing runoff, trapping sediment and pollution and, in cases where soil is condusive, infiltration of runoff into the ground.   Filter strips are typically used as one component in a treatment train and may be used either as a pre-treatment measure prior to flowing into a IMP, or can also be used as an final outet device. Filter Strips are dependent upon runoff exhibiting sheet flow while flowing across the strip, and require the vegetative element of the strip to be maintained in a healthy condition to ensure proper performance of the filter strip. The figure below shows schematically plan and section views illustrating the fundamental design of a Vegetative Filter Strip.

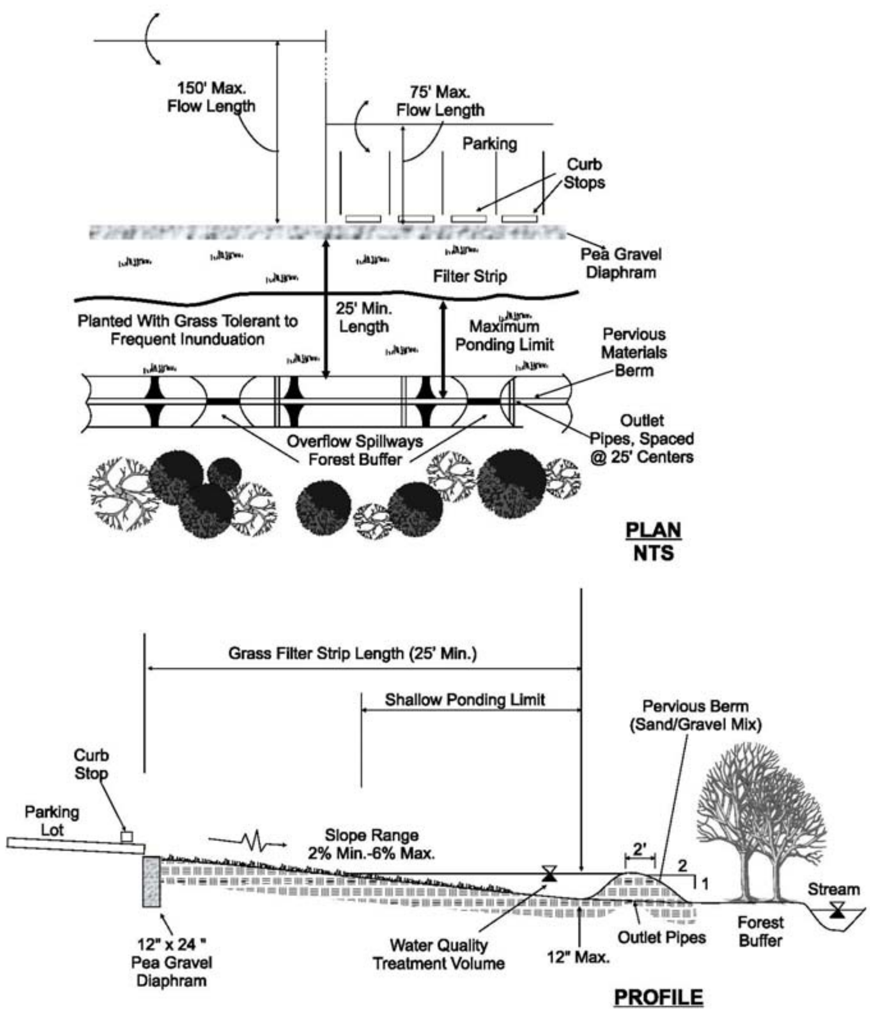


Figure 4-5. Typical filter strip (CRC, 1996).

When considering use of vegtative filter strips in a LID plan for a site, the following items should be considered in the planning and design.

- Allow storm runoff to enter vegetative filter strip as sheet flow rather than concentrated; level spreading devices are often effective to assist in maintaining uniform sheet flow characteristics at the adjacent edge of the filter strip.
- Contributing areas should have a flow length of less than or equal to 150’ for pervious areas, 75’ per impervious areas with a ratio of drainage area to filter strip not exceeding 6:1.
- Optional (permeable) berm at downstream end of filter strip can increase effectiveness over simple vegetative strip. Berm can provide for temporary storage and increase the residence time to that of a wider filter strip.
- Excessive compaction of vegetative filter strip should be avoided; in instances where filter strips are constructed in areas that have been excessively compacted, measured should be taken to be addressed the compromised soil infiltration rate such as tiling the soil and planting trees and shrubs.
- Plant material must be tolerant of inundation by surface water.
- Minimize lateral slope (Less than 1%), slope across the vegetative filter strip should be between 0.5% (minimum) and 3% (maximum).

When used properly vegetative filter strips can contribute to the creation of an attractively landscaped site that can be an important element in the treatment train in a planned LID scheme for a site. See appendix for maintenance direction and recommended maintenance schedule.

3.6 Grassed Swales / Channels

One traditional stormwater device that can easily integrated into an LID plan as an IMP is the use of grassed swales or channel. One of the most widely and longest used drainage device, the traditional drainage ditch can be integrated into a system providing an alternative to systems that use catch basins for collection and culverts to convey runoff to a treatment further downstream.

Grassed swales can be implemented in a variety of commercial, residential, and public use situations. In their simplest form, grassed swales provide little more treatment benefit to the system than simply that of pre-treatment; the greatest benefit provided to a site by the use of grassed swales however is the ability to reduce peak runoff rates and discharge volumes from a site through their ability to increase travel time (time of concentration) and allow for percolation of runoff into the bottom of the swale. Typically vegetated with densely spaced turf grass, the treatment ability, and ability to infiltrate runoff can be increased through the use of additional plant species and soil amendments where the swale then becomes more like a vegetated filter strip or a bioretention system. In addition to the ability of grassed swales to help restore and maintain the pre-development hydrology of a site, grassed swales add the benefit of requiring relatively low investment in the construction cost for this IMP as well as minimal long term maintenance costs for the developer / property owner.

Design Criteria

Grassed swales can typically be integrated into a system without involving complex design, there are however certain criteria that should be followed in order for the swale to operate effectively; these are provided below.

- Bottom channel width should be between 4 and 8 feet wide, with a shape that is generally trapezoidal or parabolic in nature.
- Channel side slopes should be a minimum of 4H : 1 V or flatter in order to allow for mowing and aid in maintenance, under no circumstance should slope exceed 3H : 1V;
- The contributing area to each swale (or segment) should be limited;
- Longitudinal slope of the channel should not exceed 4% and ideally should be between 1% and 2%;
- The dimensions of the channel should provide for a non-erosive velocity during the 2 year and 10 year storm events;
- The 10 year storm event should be contained while maintaining freeboard;
- Best suited for Hydrologic Soil Group A or B, however swales located on C and D soils can be improved through the use of soils amendments;
- A depth to water table of 2’ should be maintained;
- Grass channel should be generally aligned and parallel to the contributing drainage area;

In addition, the hydraulic capacity should be verified using Manning's Equation:

$$\boldsymbol{V = \left[\left(\frac{1.49}{n}\right) D^{2/3} s^{1/2}\right]}$$ Equation 3.6a: Manning's Equation

Where: V = flow velocity (ft./sec.)
n = roughness coefficient (0.2, or as appropriate)
D = flow depth (ft.) (NOTE: D approximates hydraulic radius for shallow flows)
s = channel slope (ft./ft.)

To solve for the design treatment flow, insert the velocity into the following equation

Q = V(WD) Equation 3.6b: Continuity Equation

Where: Q = design Treatment Volume flow (cfs)
V = design flow velocity (ft./sec.)
W = channel width (ft.)
D = flow depth (ft.)
(NOTE: channel width (W) x depth (D) approximates the cross sectional flow area for shallow flows.)

Combining Equations 3.1 and 3.2, and re-writing them provides a solution for the minimum width:

$$\boldsymbol{W = {(nQ)}\Big/{1.49 D^{5/3} s^{1/2}}}$$ Equation 3.6c: Minimum Width

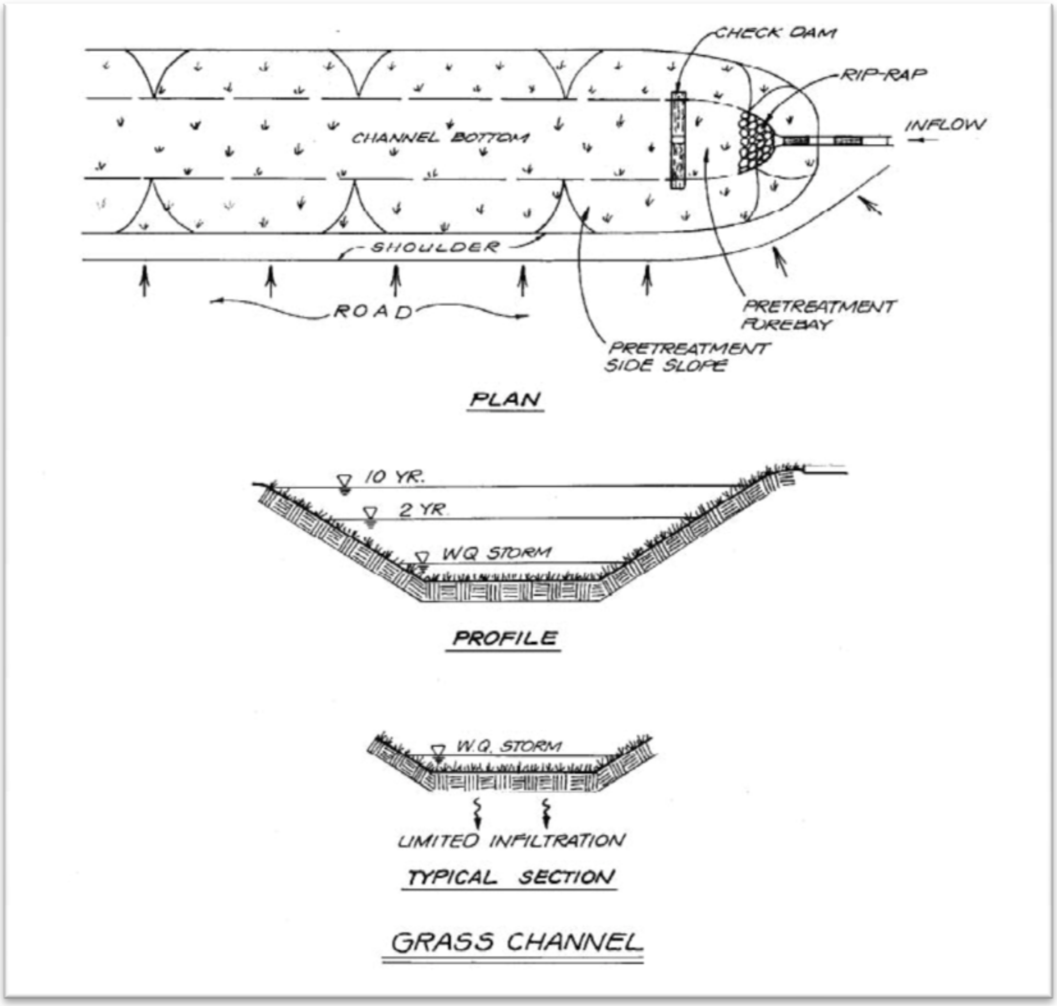
Finally solving Equation 3.6b for the corresponding velocity provides:

V = Q / WD Equation 3.6d: Corresponding Velocity

Additionally, the hydraulic residence time in the swale should be a minimum of 9 minutes prior to discharge to the next treatment facility downstream; the following equation can be used to calculate the minimum swale length needed to achieve a nine minute residence time for a given cross section;

L = 540V Equation 3.5: Grass Channel Length for Hydraulic Residence Time of 9 minutes (540 seconds)

Where: L = minimum swale length (ft.)
V = flow velocity (ft./sec.)

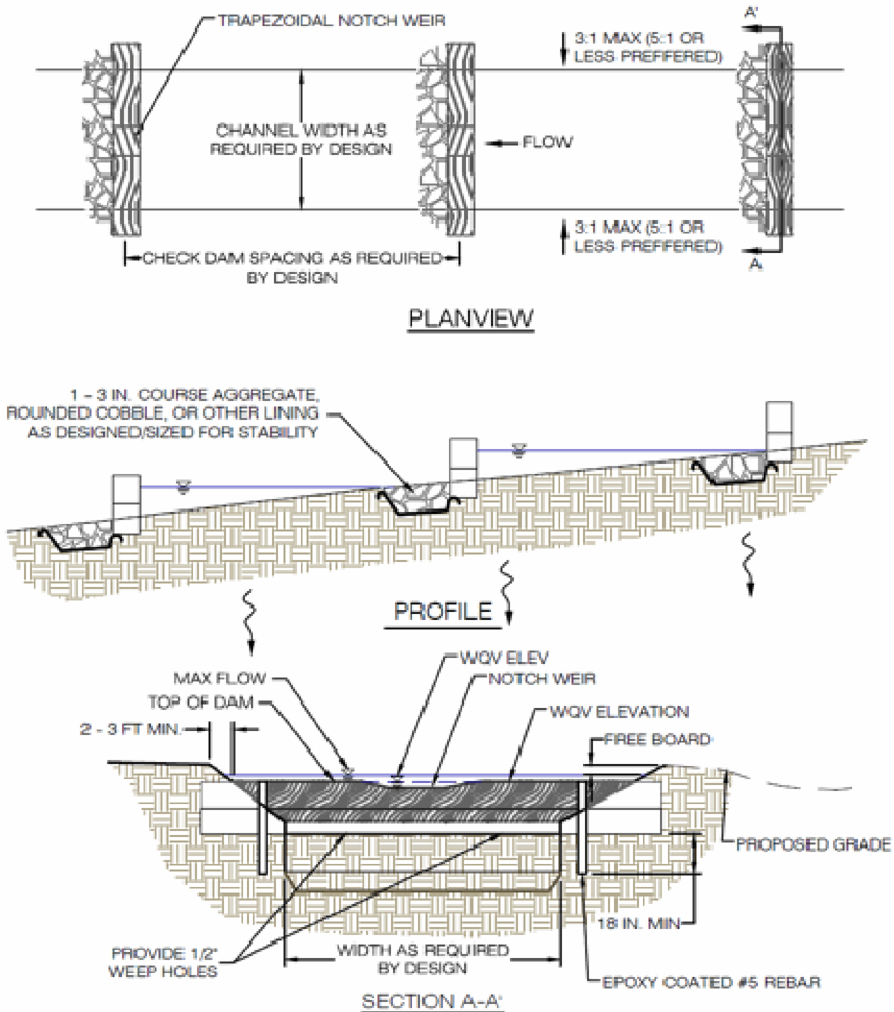


Check Dams

One of the most commonly used features that can be included with a grass swale to increase pre-treatment ability is the use of check dams. Check dams can assist by breaking up slopes, increasing hydraulic residence time in the channel, and breaking the swale into multiple segments. When including check dams in a grassed channel, check dams should be spaced as needed to increase residence time or provided any additional volume attenuation. Additional considerations that should be factor into designs that use check dams include:

- Maximum desired check dam height is 12”;
- Check dams should be spaced so that the ponding in a segment does not reach the toe of slope of the upstream check;
- Check dams should create individual channel segment that are minimum of 25 to 40 feet in length;
- Grass check dams should be easily mowable (slopes less than 4:1).

The following graphic shows a schematic plan and profile view of a grass channel that includes check dams.



NOTE: CHECK DAM CONSTRUCTED OF RAILROAD TIES, PRESSURE TREATED LOGS OR TIMBERS, OR CONCRETE.

As with all IMPs, proper functioning is reliant upon the treatment facility being properly constructed and properly maintained. Additional details for construction and maintenance and inspection forms are provided as an appendix to this manual.

3.7 Infiltration Trenches

Infiltration trenches are Integrated Management Practices that are shallow excavations typically filled with stone designed to intercept and temporarily store stormwater runoff in the stone reservoir allowing it to infiltrate into the surrounding soils and underlying native soils over a period of time typically a few days. Infiltration trenches are effective IMPs in that they serve three important functions:

- Removal sediments and their attached pollutants by infiltration through the subsurface soils;
- Reduces runoff volumes by infiltration into the subsurface soils;
- Delays runoff peaks by providing detention storage and reducing flow velocities.

When used as processes in the treatment train, infiltration trenches conform well to a variety of situations and as such and adapt well to use in urban drainage areas. Extreme care should be taken by the owner / maintenance entity to avoid clogging of the surface layer of infiltration trenches; as such it is key to include elements of pretreatment in the design and application of infiltration trenches. Typically these pretreatment devices may include vegetative filter strips or grassed swales to reduce large sedimentation from clogging the infiltration trench. Infiltration trenches are best suited for use in where smaller basins contribute runoff to the IMP; it is recommended that drainage areas should be limited to areas between 2,500 square feet and two acres in size.

When considering the use of an infiltration trench, as with any infiltration type IMP, a detailed analysis of the subsurface soils should be made. Infiltration trenches should only be used where the material is hydraulically conducive specifically those areas where the soils belong to either hydrologic group 'A' or 'B', having a permeability greater than 0.5 inches per hour. This IMP should be avoided in areas where the permeability of the soil is less than 0.25 inches per hour. Additional considerations include not including Infiltration Trenches in locations with a high water table, potential salinity hazard areas, with heavy clay soils, steep slopes, non-engineered fill, and in areas adjacent to building foundations. Infiltration trenches are generally well suited for smaller areas where the engineer needs to work the practice into a more restrictive area; on sites where larger areas area available, infiltration basins that substitute the aggregate backfill with engineered soil may prove to be a good option when including in the stormwater management plan.

Design Considerations

When including infiltration trenches in an LID plan for a site a number of considerations should be made to ensure that the infiltration trench operates properly without failure. In all instances, some nature of pretreatment should occur upstream of all infiltration practices.

Additional parameters that should be noted when designing an infiltration trench are found in Table 3.7.1 below.

Table 3.7.1: Key Parameters for Infiltration Trench Sizing and Design	
Volume Required	The Infiltration Trench should be adequately sized to contain the runoff from the 95th Percentile Storm for Ormond Beach. See Section 2.5 for establishment of 95th Percentile Storm.
Soil Permeability (Underlying)	>0.25 - 0.50 inches per hour. Generally limit use to locations where soils belonging to Hydrologic Type 'A' and 'B' are present.
Depth of Infiltration Trench	Broader, shallower trenches perform more efficiently by distributing the storm runoff over a larger surface area. The recommended range is to keep the depth between 36 and 60inches in order to practically construct without burdening too large a portion of the site. Shallower (18 inch deep) trenches can be used in areas of higher water tables, however the surface area would increase proportionately in these IMPs.
Recovery Time	Empty within three days
Backfill Aggregate	Clean aggregate > 1 ½", < 3" surrounded by engineered filter fabric.
Area Required	Although detailed design should be based upon the contributing drainage area, and the infiltration rate of the soils at the location of the infiltration trench. A good rule of thumb is that the infiltration trench has a surface area roughly 5% of the contributing basin.
Minimum Depth to Water Table	Two Feet
Slope	Limit to Flatter Areas with slopes < 5%
Outflow Structure	An overflow device should be installed that allows for system bypass to avoid erosive conditions.
Observation Well	Must be provided for monitoring. 4" PVC on footplate, capped flush with ground surface. See detail.

An infiltration trench can be sized through the use of the following equation:

$$A_{in} = (RR_v)\,\{(n)(d_{in}) + \,[(i_{soil})(t_{fill}) \div 12]\}$$

Where:

A_{in} = surface area of the infiltration trench (ft^2)

RR_v = stormwater runoff generated by 95th percentile rainfall event (ft)

n = porosity of fill media (generally use 0.32 for washed stone)

d_{in} = depth of stone reservoir (ft)

i_{soil} = infiltration rate of underlying native soils (ft/day)

t_{fill} = average time for the stone reservoir to fill (hours) – use 2 hours

The center for watershed protection provides the following plan for integrating a typical infiltration trench into the design for a small commercial site.

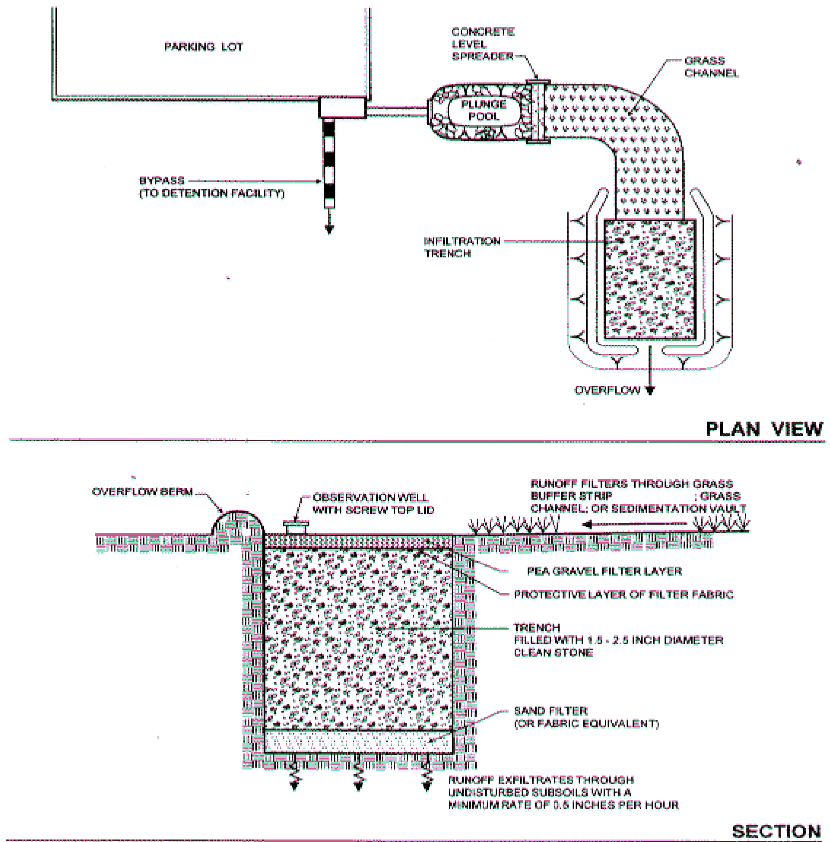


Figure 3.7.2: Schematic of Infiltration Trench

Observation Well

An observation well should be installed in each location that includes some nature of infiltration practice. A detail for an observation well is shown at right which shows the observation well consisting of a perforated pvc pipe (4" – 6" in diameter) that extends to the bottom of the infiltration trench. This observation well can be used to observe the rate of drawdown within the trench following a storm event. It should be installed along the centerline of the trench, flush with the elevation of the surface of the infiltration trench. Ideally, a visible floating marker should be installed within the observation well and the top should be capped to prevent tempering and vandalism.

Maintenance Requirements

Regular prescribed maintenance is very important for proper operation of an infiltration trench to ensure that measureable stormwater management benefits are achieved over time. A maintenance schedule and inspection form for use on projects incorporating infiltration basins is included in the appendix to this manual.

3.8 Level Spreaders

Level spreaders promote infiltration and improve water quality by evenly distributing flows over stabilized, vegetative surfaces. Benefits that can be gained through the use of level spreaders include better infiltration, higher times of concentration, and increased treatment ability. Additional benefits include the ability to disperse concentrated storm water flows, and reduce erosion. Level spreaders can be used at both as the first element in a treatment train, and at the discharge point from the system.

Examples of level spreaders are shown in the following graphics:

Simple level spreader; a level spreader like that shown in figure 3.9a can be used to promote sheet flow at the upstream end of a vegetative filter strip, bioretention area, or swale

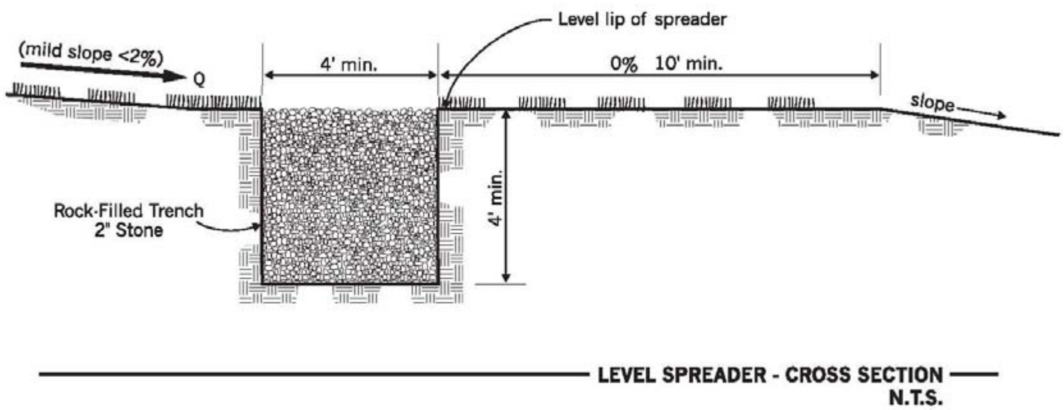


Figure 3.9a : Simple Level Spreader

Level spreaders with perforated pipes can also assist in dispersing flow across a distance and avoid point discharge.

Design considerations that should be incorporated when using level spreaders include the following:

- Incorporate as many outfalls as possible to avoid concentrating stormwater
- Avoid easily erodible soils, keep slopes downstream of level spreader below 8%.
- Provide sufficient distance after level spreader (minimum recommended = 15 feet).
- Level spreaders should be constructed on compacted soil
- Length and size of level spreaders are typically based on flow rates.
- Flow bypass should be incorporated into design to avoid adverse effects of extreme storm events.
- Erosion control should be provided at immediate downstream side of level spreader.

As stated above, the size of a level spreader is typically a function of the calculated flow rate with a minimum spreader size large enough to handle the discharge rate without restriction. For estimating the size required to handle flow some rules of thumb are:

COVER:	GRASS OR THICK VEGETATION	FORESTED WITH LITTLE OR NO GROUND COVER
LENGTH:	13 lineal feet of spreader for every one cubic feet per second (cfs) of flow	100 lineal feet of spreader for every one cfs flow
SLOPE:	Slopes of eight percent or less from level spreader to toe of slope	Slopes of six percent or less from level spreader to toe of slope. For slopes up to 15 percent for forested areas and grass or thick cover, install level spreaders in series. Use above recommended lengths.

For further refinement of level spreader sizing use the following equation:

$$L = Q_p / Q_l$$

Where:
L = Length of level spreader pipe (ft.)
Q_p =design inflow for level spreader (cfs)
Q_l = level spreader discharge per length (cfs/ft)

AND

$$Q_L = Q_O \times N$$

Where:
Q_L = Level Spreader discharge per length (cfs/ft)
Q_O = perforation discharge rate (cfs)
N = Number of Perforations per length of pipe, based on pipe diameter (#/ft)

AND $Q_O = C_d \times A \times \sqrt{2gH}$

Where: Q_O = perforated discharge rate (cfs)
C_d = Coefficient of discharge (typically 0.60)
A = Cross sectional area of one perforation (ft^2)
g = acceleration due to gravity, 32.2 ft/sec^2
H = Head, average height of water above perforation (ft)

3.9 Permeable Pavers / Pervious Pavement

One type of structural IMPs that consistently is the subject of attention is the use of alternative materials in the construction of parking lots, driveways, and roadways. Traditional pavement (asphalt or concrete) is mostly impervious in nature; as a result, virtually all rainfall that falls on the surface becomes runoff. Pervious differs from traditional pavement in that it lacks most of the fine material found in conventionally prepared materials. As a result, systems that utilize pervious pavement systems temporarily store all or a portion of the water quantity before allowing it to infiltrate into the surrounding parent soil or in certain cases be conveyed into the storm drain system through an under drain manifold system rather than displacing the water as runoff.

When included in an LID plan for a site, pervious pavement can be a valuable part of the treatment train. Operating at the front of end of the overall system, permeable pavement can benefit a site by reducing runoff by infiltration through the pavement section which in many cases includes an aggregate layer below the pavement surface. Permeable pavement can also provide limited treatment benefit to the system, acting similarly to a sand filter, the pavement filters the water by forcing it to pass through different aggregate sizes as well as filter fabric. The ability or efficiency of the pavement with regards to infiltration and filtration is largely dependent upon the overall permeability of the pavement section which includes the permeability of the underlying soil. Because of this, there is an advantage to utilizing permeable pavement in locations where the native soil is Hydrologic Group ‘A’ or ‘B’, and although some compaction is necessary, to limit the compaction of the pavement base. For this reason, permeable pavement is best suited for the following applications:

- Parking Spaces Within Parking Lots
- Low Intensity Drive Aisles
- Sidewalks, Walkways, and Trails
- Residential Driveways
- Low Traffic Street

In general, the structural devices that comprises pervious pavement falls into one of two categories; pervious paving, and pervious pavers each of which will be discussed in detail below.

Pervious Pavement

The most widely used type of permeable pavement in Florida has been pervious concrete which is similar in form to conventional concrete in structure and form consisting of an open graded surface course bound together by Portland cement. The typical thickness varies from four inches for sidewalks and bike paths and up to six to eight inches f or traffic bearing areas such as parking lots, driveways, and low impact roadways. This pavement has a permeability that is many times greater than the underlying soils due to the high void ratio (15% - 25% compared to 3% - 5% for conventional concrete) allowing rainwater to pass directly through . Typically, a base layer is not required in order for structural support, it may be deemed beneficial by the designer to include a base consisting of aggregate in order to increase the stormwater storage capacity. Similar to pervious concrete, porous asphalt which consist of an open surface course bound by asphaltic cement, the thickness of which is typically recommended between three and seven inches, and like pervious cement has a void ration of 15% to 25%. Given the uncertainty of the porous asphalt to maintain its structure during warmer summer months in Florida its use is not recommended for projects within the City of Ormond Beach.

Permeable Pavers

The second category of permeable pavement is that of permeable pavers. Permeable pavers in turn fall in to one of two general types interlocking concrete pavers and grid pavers. Permeable interlocking pavers are paver blocks that are installed in a way that permits runoff to pass through regularly spaced openings into an underlying stone reservoir. The spaces between pavers account for 8% to 20% of the surface area of the pavement, with the voids filled by pea gravel. This type of pavement is well suited for parking spaces, residential driveways, and accent areas in other traffic ways such as entrances to commercial properties and residential developments.

The second type of permeable pavers is that of grid pavers. The traditional grid paver being concrete grid paver (turf block) which are pre-cast concrete grids that are filled with gravel, top soil, or turf. Having a void ratio of between 20% and 50%, the media used to fill the voids has a tremendous impact on the overall permeability of the paved area. These grids are usually set in a pea gravel bedding layer (typically one to two inches in depth) with an underlying stone reservoir layer. Recent advances have also introduced plastic reinforcing grids pavers. Similar in principle to concrete grid pavers, the flexible interlocking units usually contain openings that allow for void ratios that can exceed 90% which allows rainfall and stormwater to flow through the grid system. Given the high void ratio, the fill material plays an even larger role in influencing the behavior of runoff and the permeability of the grid pavement system. Interlocking grid paver systems are most commonly used in areas of parking, specifically in areas of overflow parking for uses such as churches and recreational and educational facilities., it can also be used in areas of required secondary access to a development or for emergency access drives on properties.

Design Considerations

Permeable surfaces are well suited to many different development types, however there are a number of considerations that should be evaluated in order to determine the appropriateness of use in a given situation, at a specific location, and to determine which type of permeable surface best applies to the development. Above and beyond all criteria, permeable surfaces should only be used in situations where they replace traditional impervious paving surfaces. They are not suited to, and should not be as considered for use as devices that specifically receive runoff generated elsewhere on site. Permeable surfaces do not by nature have the strength that traditional paved surfaces do, as such the use of permeable surfaces should be limited to low traffic areas, and use should be avoided in areas of heavy regular truck traffic or where sharp turning movements are expected. Additional considerations include:

- Slopes should be kept shallow (less than five percent),
- Avoid use in areas where the water table is close to the surface (keep seasonal high water level greater than 24 inches below surface),
- The pavement system should be designed to completely drain within 24 hours; this can be achieved by insuring that infiltration rates exceed 0.5 inches per hour, or by designing the system to include an under drain where needed,
- The surface infiltration rate of a site should be a minimum of 1.5 inches per hour at time of construction, with periodic testing by a registered professional engineer occurring to show continued compliance.
- An appropriate aggregate base should be include in the design to meet the storage and structural needs of the pervious pavement area,
- Adequate distance should be maintained from building foundations, property lines, wells, septic systems, and stormwater facilities.

In order to insure proper operation of the pervious pavement area, testing locations should be installed with the pervious pavement. An example of the testing device that should be installed would be an embedded ring infiltrometer. At least two test locations should be installed per acre, with a maximum required number of test locations being ten per site. The locations of these, along with type and/or details for construction should be provided on the LID Plan for the site. Credit as an LID IMP, can only be provided for a site using pervious pavement surfaces if the appropriate accommodations are made for periodic testing.

Construction Considerations

A successful pervious pavement system relies upon the successful installation of the pavement by a skilled and trained contractor familiar with the installation of pervious pavement systems. This is most critical when pervious pavement is called for in the design of a site. Additionally, the contractor should plan construction staging in order to minimize unnecessary soil compaction; keeping heavy vehicular traffic out of permeable pavement areas prior to, during, and after construction. Excavation should be limited to the area of permeable surface installation, the ground should be properly scarified, and all tree roots should be trimmed around the perimeter of the area to avoid issues with the installation of filter fabric and the stone reservoir.

Maintenance of Permeable Surfaces

Establishment of a responsible maintenance entity and establishment of a thorough maintenance schedule and directions are critical to the long term successful operation of permeable pavement surfaces. Clogging is the main source of permeable pavements not operating to design standards as smaller particles deposited by vehicular traffic, foot traffic, wind deposition, or runoff flow can become trapped in the voids between the large particles of the permeable pavement. One item that should be stated in any maintenance agreement is that in areas of pervious pavement, no impervious sealants or top layers should be placed over the permeable pavement surfaces noted on the LID Plan.

Maintenance guidance for permeale surface areas and inspection forms for use when permeable surface areas are incorporated into a plan is included in the appendices to this manual.

Additional Considerations

One additional consideration that is appropriate to mention with the discussion of permeable parking surfaces are the use of alternative planning techniques when designing paved surface areas specifically parking lots. By reducing the parking lot footprint, the self provided credit resulting from reducing the curve number can occur. Some of the techniques that can be employed to reduce the footprint of a parking facility include:

- Rethinking of Parking Design and needs; an analysis of parking needs based on a survey of actual parking requirements proven in existing sites can result in a reduction of required parking spaces for a site. Under no circumstances should the number of spaces provided exceed 110% of the parking spaces required by code. Careful analysis of parking needs can result in staff permitting plans that provide fewer spaces than otherwise dictated by code.
- Minimization of parking stall dimensions; reducing depth to eighteen feet, and including compact parking spaces where appropriate can lead to a significant reduction in the total impervious area called for on site.
- Shared parking agreements; by encouraging and creating agreements between complementary sites, peak parking needs can be met by sharing lots with adjacent sites whose peak demand occurs at offset times.

3.10 Soil Reforestation / Revegetation

In site reforestation / revegetation, the developer plants a combination of trees, plants, shrubs, and grasses to restore disturbed pervious areas to a condition that closely mimcs its native state. When integrated into a site, reforestation to establish areas on a site that can grow into mature plant communities the developer creates a device that can intercept rainfall, increase evaporation and transpiration rates slow and filter stormwater runoff, and help increase soil infiltration rates. In addition to stormwater benefits of reduced stormwater runoff rates, volumes, and pollutant loads, reforestation can also provide a habitat for plant and animal species.

A project designer / landscape architect can take many different approaches in reforestation of a a portion of a site,included in these are:

Creation of Native Plant Communities

Reforestation

Savanna Restoration

Best suited for larger preservation areas, and likely not applicable to smaller infill or urban redevelopment projects, the creation of a plan that considers the constraints placed upon the plan by the site in its native, and if disturbed, current condition is necessary for for successful utilization of soil reforestation. One approach to including soil restoration is to follow the following sequence of steps and processes.

Analysis of the Physical Conditions of the Site
Knowledge of the site's hydrology topography, hydrology, and underlying soils will help direct the ideal location for reforestation as well as the selection of comlplementary plant types to create an effective and aesthtically pleasing plan. Important resources in the conceptual planning process include the Soil Survey of Volusia County, USGS and Volusia County Topographic maps, as well as inspection of the site.

Analysis of the Vegetative Communities
A survey of the existing vegetation at the site, if not yet cleared, or of vegetation elsewhere on site and in the immeadiate vicintiy showuld be made to help create a strategy for the revegetation. Include in this survey the desirable species that thrive in the area, those invasive or undesirable species that should be eliminated in the replanting and controlled in the maintenance of the reforested area.

Map the Site
Take a pre-development survey noting the physical features of the site includign water bodies, significant slopes, specimen and historic trees, as well as adjacent uses, utilities and other features that can be an asset or present a challenge in the design and implementation of the plan.

Create a Design
Consider and balance the needs of the developer, which includes the future proposed use of the property with the environmental features that can benefit from the implementation of reforestation. Strong emphasis should be placed upon the role the reforested area has in accepting runoff from the proposed site and the watershed to which it discharges. Keep the following parameters in mind with the preparation of the plan:

- Proper Siting of the Reforested Area – As stated elsewhere, minimization of the develoment footprint is an important consideration when developing an LID Plan; in addition, a succcessful LID Plan incorporating reforestation should be of a significant size (greater than 10,000 square feet), efforts should be taken to tie multiple reforested areas on a site or more than one sites together possibly creating parks, trails, or wildlife corridors. Consideration should also be made with regards to the acceptance of runoff from a site.
- Proper Plant Selection and Placement – Reforestation / revegetation efforts should achieve 75% cover within the first year after installation. Plant selection should mimic the native vegetative communities of the site and surrounding areas, with a mix of plant species (shrub and tree) planted at approximately eight feet on center. Ideally trees plantings should be 18 – 24 inches in height with shrubs 12 – 18 inches in height planted upon establishment of groundcover.
- Consider use of interim species to ensure such as annual rye to ensure adequate stabilization of the site while slowing growing species and groundcovers are being established.
- Preserve natural topography of the site, taking additonal care to minimize the use of steep slopes.

Proper Site Development

In addition to limiting the footprint of the development, it is important to limit the compaction that occurs in areas such as those targeted for reforestation. In areas that have been disturbed, soil ammendment by adding compost or other ammendments may be beneficial in addtion to reestablishment of long term soil capacity and pollution removal. The proper steps should eb taken, through mechanical means, and the use of herbicides to prepare revegetated areas and prevent the growth of onvasive weeds by weeding prior to planting and during the first year.

Prepare and Communicate a Management and Maintenance Plan for the Reforested Area

Include requirements for weeding, mowing, irrigation, trimming and replacement of the species planned for the reforested area. A description of the reforested shoul be provieded as an attachement to the permit creating a conserved area. The maintenance of these areas should not be considered "turf management" and it should be emphasized to those responsible for maintenance of the site, specifically with these areas, that care should be taken to manage the areas in undisturbed natural states.

Maintenance guidance and an inspection form for use when reforested / revegetated areas are incorporated into a plan is included in the appendices to this manual.

Section 4
Plan Requirements for LID

Section 4.1: Plan Requirements

Chapter Four of the Land Development Code of Ormond Beach Specifies, in general terms the requirements for submittal of Site and Subdivision plans proposed for construction within the City. When a developer elects to include Low Impact Development techniques in the plan for development there are certain items specific to LID that should be included in the submittal for site plan review. In addition to those site plan items required for submittal by Chapter 4, an LID plan for the project should be submitted as well as Operation and Maintenance (O & M) documents that detail the entity responsible for inspections and maintenance of the IMPs, an inspection schedule, and maintenance requirements.

Section 4.2: LID Plan

Any project submitted for approval within the City of Ormond Beach is required to provide a site plan package that contains specific elements required of the submitted plan in order to facilitate review and ensure proper construction of the site and all required elements. For those projects that elect to employ LID, a specific LID plan is required for inclusion in this plan set. This plan will contain certain specific elements that will identify those IMPs included on the site, the portion of the site that those IMPs cover, and details for the construction of those specific IMPs. This LID plan is not simply a construction plan , in addition to providing guidance for the development of the site, this plan should also be included in the O & M Documents and be incorporated for reference in the inspection schedule and to assist in future maintenance activities.

The format of the LID plan should follow that of the other plans included in the plan set and following the following general guidelines as specified in Chapter 4 of the LDC.

1. Plan sheet should be 24”x36” in size,
2. Project Name, consistent with application should be shown on sheet,
3. North Arrow should appear on sheet,
4. Scale should be no smaller than 1” = 50’, and be both stated and graphic,
5. Date,
6. Professional seal should be included on all plans.

Additionally, the following items specific to this plan should be included on this plan or with adjacent plan sheets;

1. Each IMP should be identified by type and with a unique reference ID that can be used to refer to the IMP in O & M documents,
2. The boundaries of the drainage basins should be outlined and identified by the IMPs that service the basin,
3. Identify any structures either individually or as a group of structures that are components of the IMP,
4. Refer to any landscape elements crucial to the IMP,
5. A reduced size copy (scaled accordingly) is acceptable for inclusion in the O & M documents,
6. Provide details for any and all IMPs included in the plan.

An example is provided on the sheet that follows illustrating the elements required for inclusion on the LID Plan.

Page Left Intentionally Blank
Replace with 11”x17” LID Plan

Standard details for construction of many IMPs are provided in Appendix ‘B’ of this Manual, electronic versions of these details are available from the City.

Section 4.3: Operation and Maintenance Documents (O & M)

As previously discussed, the proper operation and maintenance of the IMPs is as critical to the success of a project following Low Impact Design Principles as is the design of the system and site. Those properties that incorporate LID into their sites are required to provide to the City for the review and upon satisfactory review O&M documents that include the following items:

1. LID Plan – As discussed in Section 4.2 of this manual, this plan will depict the locations of all IMPs as well as the component elements of IMPs and the portions of the property that each IMP is responsible for treating.
2. Maintenance Covenant – A -recorded document, this covenant shall establish the responsible entity for ensuring that the IMPs included in the LID plan continue to be operational and are maintained in perpetuity.
3. Maintenance Schedule – An outline that provides the intervals necessary for inspection of the individual IMPs and their component elements. Included with this will be the date for the Annual Certification of the system to the City and any other jurisdiction and any other jurisdictions that may apply.
4. Maintenance Requirements – Outline sheets that provide the maintenance entity with guidance of the maintenance and housekeeping steps necessary at prescribed intervals to ensure proper operation of the LID system on-site.
5. Record Keeping – A portion of the O&M Manual shall be devoted to recording inspections of the system as well as any modifications and maintenance activities that were required for its proper operation.
6. Inspection Forms – Copies of those forms required for certification of the site to the City and any other required entities shall be included.
7. Outreach Materials – In order for a development to successfully sustain LID techniques planned for installation, it is important for all stakeholders in a project to understand the IMPs and each individual’s role with the site. Contractors should understand the proper installation methods, developers should understand the value of proper installation and maintenance of the IMPs, and future / potential property purchasers and owners should be made aware of the value that the inclusion of LID in the development of site has to the owner as well as the importance of ensuring that future maintenance and operation occurs.

Included in Appendix ‘C’, O&M Documents of this manual are both a sample maintenance covenant that includes all language required by the City for this document, as well as maintenance requirements for many IMPs that would be suited for use in the City of Ormond Beach. These maintenance requirement sheets have been assembled from researching the separate IMPs by City staff, and reflect the inspection and maintenance activities and intervals applicable for systems constructed within Central Florida.

The City will maintain a database of all LID properties and the ownership and responsible maintenance entity for each property. Within this database will be the submitted LID plans for each site as well as an inventory of all IMPs associated with each respective site. It is the responsibility of the owner to ensure that notification is made to the City when ownership for a property changes, a copy of city standard form *Transfer of Maintenance Entity, LID Sites*, shall be submitted at the time of property ownership transfer or change to maintenance entity; a copy of this form is included in Appendix ‘C’.

Section 4.4: Inspections

Inspection of the system in accordance with Maintenance Covenants shall be the sole responsibility of the Property Owner or Stated Maintenance Entity. Because IMPs vary in their inspection frequency, the inspection schedule shall state a certification period and designate a date range for the certification of the system. This inspection of the full system shall occur on an annual basis within one month of the beginning of the rainy season for Volusia County (March – November). It is the responsibility of the maintenance entity to submit an inspection report to the City; although this inspection of the full system is a self certification, property owners are highly encouraged to engage the services of a registered professional engineer or some other qualified professional with experience in the design in inspection of stormwater facilities to inspect the elements of the system, and make recommendations as needed to ensure that proper operation of the system is maintained.

Included in Appendix ‘C’, is the form *City Standard Inspection Form for Inspection of LID Sites*, which should be included in the O & M Manual as reference, and for submittal at the time of annual self certification of the system.

Section 4.5: Outreach

One additional element to O&M that should be discussed is the importance of outreach and education. Because the IMPs associated with LID require greater involvement on behalf of the stakeholders, it is important that those involved with an LID development are informed and understand the specific elements involved with the system.

For commercial properties, or those under a single maintenance entity the new ownership entity should be made aware of what comprises the LID system and it’s IMPs prior to assuming ownership and maintenance responsibility; in instances where multiple entities are involved in the operation of an LID system, i.e. a residential subdivision IMPs are located on multiple lots; the HOA should take steps to educate the individual owners on their responsibilities in the overall development. Ideally, the O&M Manual should provide a guidebook to the steps that must be taken in order to successfully maintain and operate the site; the inclusion of materials that educate the stakeholders on the specific LID elements included in the site, as well as material that effectively communicates the activities necessary to operate the system are critical to the future success of a site design using the elements of LID.

Section 5
Appendices

Appendix 'A'
Definitions

The following terms are used throughout this manual, definitions applicable in the context of Low Impact Development are provided for clarification and understanding.

Artificial Drainage System: Any canal, ditch, culvert, dike, storm sewer or other man-made facility, which tends to control the flow of surface water.
Average Annual Load Reduction: An estimate of the long term average reduction in annual pollutant loading provided by a stormwater management practice; typically expressed as a percentage.
Average Annual Rainfall: The long term rainfall that occurs annually.
Base Flood: The flood having a 1 percent chance of being equaled or exceeded in any given year. The term is synonymous with "100-year flood" and "regulatory flood".
Density: The number of residential units permitted per gross acre of land as determined by City of Ormond Beach Zoning Regulations.
Base Flood Elevation (BFE): The computed elevation shown on a Flood Insurance Rate Map that indicates the water-surface elevation resulting from a flood that has a 1 percent or greater chance of being equaled or exceeded in any given year.
Cistern: A closed reservoir or tank used for stormwater harvesting
Detention: The collection and temporary storage of stormwater or surface water for subsequent discharge at a rate that is less than the rate of inflow.
Detention with Biofiltration: A landscaped depression area with a separate inlet and outlet (underdrain). Depressions are often linear and may be connected in series. Storage volume recovery of the system is through an underdrain system. Other terms applied to similar practices include biodetention, bioswales, and vegetated swale.
Development Activity or Development: Development activity or development means any of the following activities:

A. Construction, clearing, filling, excavating, grading, paving dredging, mining, drilling or otherwise significantly disturbing the soil of a site.

B. Building, installing, enlarging, replacing or substantially restoring a structure, impervious surface, or water management system, and including the long-term storage of materials.

C. Subdividing land into two or more parcels.

D. A tree or vegetation removal for which authorization is required under this Code.

E. Erection of a sign for which authorization is required under this Code.

F. Alteration of a historic property for which authorization is required under this Code.

G. Changing the use of a site so that the need for parking is increased.

H. Construction, elimination or alternation of a driveway on a public street.

Directly Connected Impervious Area (DCIA): Those impervious areas that are hydraulically connected to the conveyance system and them to the basin outlet point without flowing over pervious areas.

Drainage System, Natural: Watercourses or those wetlands which convey water to natural points of discharge or which store water.

Drainage Systems (Surface Water or Stormwater): All artificial stormwater control systems, facilities and structures including, but not limited to, basins, canals, conduits, channels, culverts, dams, impoundments, pipes, reservoirs, swales and other such works or natural features such as wetlands, creeks, rivers, and lakes that provide collection, drainage, conveyance, or other surface water management capabilities located inside publicly owned rights-of-way or easements.

Drip Line: A vertical line running through the outermost portion of the tree crown extending to the ground.

Driveway: A paved area on a site used for ingress and egress of vehicles

Drought-Tolerant (including Low-Water Use) Plant or Tree: Native plants or trees capable of surviving extended periods with little or no rainfall, as typically experienced in Central Florida.

Easement: A grant to another party by a property owner of the right to use land for a specific purpose, such as, but not limited to, drainage or placement of utility lines, protection of conservation areas, or movement of vehicles or people.

Equivalent Impervious Area (EIA): The area of a completely impervious watershed that would produce the same volume of runoff as the actual watershed.

Engineer: A person professionally licensed by the state to practice engineering.

Existing Condition: The physical condition of the site immediately before development, redevelopment, or a clearing or other impact to the site commences.

Exotic: A species introduced to Florida, purposefully or accidentally, from a natural range outside of Florida.

Filling: The depositing of any materials by any means into water, wetlands, floodplain, or upland area.

Finished Grade: The completed surface of lawns, walks, and driveways brought to grade as shown on building plans or designs relating thereto.

Floodplain: Any land area susceptible to being inundated by flood waters from any source.

Freeboard: A factor of safety, expressed in feet above a flood level which is applied for the purpose of floodplain management. Freeboard is used to compensate for the many unknown factors that could contribute to flood heights greater than those calculated for a selected flood or floodway conditions.

Grade, Finished: The final elevation of the ground surface after development.

Grade, Natural: The elevation of the ground surface in its natural state before man-made alterations.
Greenroof: A roof built to the specifications of this manual that includes at minimum vegetation, media, and a waterproof membrane. To receive water quality credit, it is specifically built with a cistern or water holding system from which irrigation is provided.
Groundwater: Water beneath the surface of the ground whether or not flowing through known and definite channels.

Hydric Soil: A soil that is saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions in the upper part that favor the growth and regeneration of hydrophytic vegetation (US Department of Agriculture - Soil Conservation Service 1985). Hydric soils that occur in areas having positive indicators of hydrophytic vegetation and wetland hydrology are wetland soils. In addition, soils are hydric according to the soil profile which obtains hydric characteristics of organic matter accretions at the soil surface, high organic matter content in soil surface layer, and gray soil matrix color near the surface layer (soils which undergo saturation for a sufficiently long period of time usually give distinct gray color resulting from oxidation and reduction processes).

Integrated Management Practice (IMP): A Low Impact Development practice or combination of practices that are the most effective and practicable (including technological, economic, and institutional considerations) means of controlling the predevelopment site hydrology.

Impervious Area: A hard surface area (e.g., parking lot of rooftop) that prevents or retards the entry of water into the soil, thus causing water to run off the surface in greater quantities and at an increased rate of flow.

Infiltration: The downward movement of water from the land surface into the soil.

Hydrologic and Hydraulic Engineering Analysis: An analysis performed by a professional engineer in accordance with standard engineering practices as accepted by FEMA, for the purpose of determining base flood elevations and/or floodway boundaries.

Impervious: Surface material incapable of being penetrated by moisture and preventing the percolation of water to sub-surface areas.

Littoral Zone: That portion of any lake, borrow pit, or pond measured from seasonal high water elevation in water bodies where water elevation is not controlled by structures to a depth of three feet. Littoral zones also include those areas in salt or brackish water from the mean high water to a depth of three feet.

Low Impact Development: A stormwater management approach that uses a suite of hydrologic controls (structural and non-structural) distributed throughout the site and integrated as a treatment train (i.e., in series) to replicate the natural hydrologic functioning of the landscape which ranges in effective area from the residential lot level to the entire watershed.

National Geodetic Vertical Datum (NGVD) of 1929: A vertical control used as a reference for establishing elevations, referred to as the Sea Level Datum of 1929.

Natural Area: An area identified on an approved site plan containing natural vegetation which will remain undisturbed when the property is fully developed.

Natural Flow: The rate, volume, and direction of the surface or groundwater flow occurring under natural conditions.

North American Vertical Datum (NAVD) of 1988: A vertical control used as a reference for establishing elevations.

Nutrient-adsorption layer: A layer included in green roof and pervious pavement systems, which absorbs nutrients thereby reducing the nutrient loading from the system.

Parking Aisle (or Aisle): An area within a parking facility intended to provide ingress and egress to parking spaces.

Parking Area, Off-Street: All areas located outside of right-of-way which are designed and constructed for the circulation and parking of automobiles, motorcycles and bicycles, unless otherwise authorized by the City for other vehicles (i.e., boats, heavy equipment, etc.), and all land upon which vehicles traverse as a function of the principal uses.

Parking Bay: A parking bay is a single drive aisle with head-on access to parking spaces on one or both sides of the aisle. The parking bay is comprised of the parking stall depth and the aisle

Parking Lot: An off-street, ground level area for the temporary, transient storage of private passenger motor vehicles and such area has been approved by the City for parking, as such term is defined in this Article.

Parking Space or Stall: An area, enclosed or unenclosed, sufficient in size to store one motor vehicle and permitting the necessary ingress and egress of a motor vehicle.

Paved Area: An improved area consisting of asphaltic concrete, concrete, brick or similar material, acceptable to the City Engineer, which is intended or designated for parking, maneuvering and/or vehicular movement, and including pedestrian access ways immediately adjacent to such areas.

Pavement: That part of a street composed of vehicular travel lanes having an improved surface of asphalt, concrete, brick or other paving materials acceptable to the City Engineer.

Permeable: Soil or other material that allows the infiltration or passage of water or other liquids.

Periodically Inundated Soil: A hydric soil where presence of mucky texture, peat, muck, or mucky peat layer in the soil surface is strongly indicated. The water table will rise to the ground surface on a regular and periodic basis.

Pervious Pavement: A pavement system that allows stormwater to infiltrate into the parent soil.

Predevelopment: Conditions that exist on a site at the time of permit application.

Pretreatment: Stormwater volume and/or water quality controls applied upstream from or before capture, storage, treatment, infiltration, and/or harvesting by a subsequent stormwater management practice in a treatment train.

Rational Method: The rational method is the most widely used procedure for designing small drainage structures and is mathematically typically expressed as Q = CiA, where "Q" is the peak rate of runoff (cu. ft./sec), "C" is the runoff coefficient, "i" is the rainfall intensity (inches/hr.) and "A" is the area of the drainage basin (acres).

Receiving Bodies of Water: Any water bodies, watercourses or wetlands into which stormwater is discharged and surface waters flow.

Runoff: Water from rain, melted snow, or irrigation that flow over the land surface.

SCS Method: Soil Conservation Service curve number method for calculating stormwater runoff based on Type II (Florida Modified) storm distribution.

Storm Sewer: A sewer that carries storm and surface waters and drainage, but excludes sewage and polluted industrial wastes.

Surface Water Management Systems: All artificial stormwater control systems, facilities and structures including, but not limited to, basins, canals, conduits, channels, culverts, dams, impoundments, pipes, reservoirs, swales and other such works or natural features such as wetlands, creeks, rivers, and lakes that provide drainage, water storage, conveyance, treatment or other surface water management capabilities located outside publicly owned rights-of-way or easements.

Turf Grass: In horticulture, the surface layer of soil with its matted, dense vegetation, usually GRASSES grown for ornamental or recreational use. Such turf grasses include Kentucky BLUEGRASS, creeping BENT grass, fine or red fescue, and PERENNIAL ryegrass among the popular cool-season types, and Bermuda grass, zoysia grass, and St. Augustine grass among the warm-season types. Turf grasses are often grown on turf, or sod, farms. Plugs, blocks, squares, or strips are cut and transplanted to areas where they quickly establish and grow. Lawns are fine-textured turfs that are mowed regularly and closely to develop into dense, uniformly green coverings that beautify open spaces and provide sports playing surfaces (e.g., tennis lawns, golf and bowling greens, and racing turfs).

Watershed: The topographic boundary within which water drains into a particular river, stream, wetland, or body of water.

Wetlands: Those areas that are inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soils. Soils present in wetlands generally are classified as hydric or alluvial, or possess characteristics that are associated with reducing soil conditions. The prevalent vegetation in wetlands generally consists of facultative or obligate hydrophytic macrophytes that are typically adapted to areas having soil conditions described above. These species, due to morphological, physiological, or reproductive adaptations, have the ability to grow, reproduce, or persist in aquatic environments or anaerobic soil conditions.

Wet Retention: A retention/detention pond having a bottom elevation below the dry season surface water level. Storage area is measured from the wet season high water line to the top elevation.

Appendix 'B'
Declaration of Covenants - Maintenance Schedules & Inspection Forms

DECLARATION OF COVENANTS
For Low Impact Design Storm and Surface Water Facility, and Integrated Management Practice Maintenance

THIS DECLARATION OF COVENANTS, made this
_________________ day of ________________, 20___, by
____
____
Hereinafter referred to as the Covenanter(s) to and for the benefit of the City of Ormond Beach, Florida and its successors and assigns hereinafter referred to as the City.

WITNESSETH:
WHEREAS, the City is authorized and required to regulate and control the disposition of storm and surface waters within the St. Johns River Water Management District set forth in the Land Development Code for the City of Ormond beach: and

WHEREAS, Covenanter(s) is (are) the owner(s) of a certain tract
or parcel of land more particularly described as:
____
____
____
____
____
____

being all or part of the land which it acquired by deed dated
___________________________________ from
____
_______________________________grantors, and recorded among the Public Records for Volusia County, Florida in Official Records Book _______________________
Page(s) _____________________such property being hereinafter referred to as the "the property"; and

WHEREAS, the Covenanter(s) desires to construct certain improvements on its property which will alter the extent of storm and surface water flow conditions on both the property and adjacent lands: and

WHEREAS, in order to accommodate and regulate these anticipated changes in existing storm and surface water flow conditions, the Covenanter(s) desires to build and maintain at its expense, a stormwater management plan design in a manner consistent with the Low Impact Development techniques, presenting a plan consistent with the City of Ormond Beach's Low Impact Design Manual, more particularly described and shown on plans titled
____
____

and further identified under approval number ___________________________________;
and ___________________________________.
WHEREAS, the City, has reviewed and approved these plans subject to the execution of this agreement.

NOW THEREFORE, in consideration of the benefits received by the Covenanter(s), as a result of the City approval of his plans. Covenanter(s), with full authority to execute deeds, mortgages, other covenants, and all rights, title and interest in the property described above do hereby covenant with the City as
follows:
1. Covenanter(s) shall construct and perpetually maintain, at its sole expense, the above-referenced storm and surface management facility and system in strict accordance with the plan approval granted by the City.

2. Covenanter(s) shall, at its sole expense, make such changes or modifications to the storm drainage facility and system as may, in the City discretion, be determined necessary to insure that the facility and system is properly maintained and continues to operate as designed and approved.

3. The City its agents, employees and contractors shall have the perpetual right of ingress and egress over the property of the Covenanter(s) and the right to inspect at reasonable times and in reasonable manner, the storm and surface water facility and system in order to insure that the system is being properly maintained and is continuing to perform in an adequate manner.

4. The Covenanter(s) agrees that should it fail to correct any defects in the above-described facility and system within ten (10) days from the issuance of written notice, or shall fail to maintain the facility in accordance with the approved design standards and with the law and applicable executive regulation or, in the event of an emergency as determined by the (State, County, City) in its sole discretion, the (State, County, City) is authorized to enter the property to make all repairs, and to perform all maintenance, construction and reconstruction as City deems necessary. The City shall then assess the Covenanter(s) and/or all landowners served by the facility for the cost of the work, both direct and indirect, and applicable penalties. Said assessment shall be a lien against all properties served by the facility and may be placed on the property tax bills of said properties and collected as ordinary taxes by the City

5. Covenanter(s) shall indemnify, save harmless and defend the City from and against any and all claims, demands, suits, liabilities, losses, damages and payments including attorney fees claimed or made by persons not parties to this Declaration against the City that are alleged or proven to result or arise from the Covenanter(s) construction, operation, or maintenance of the storm and surface water facility and system that is the subject of this Covenant.

6. The covenants contained herein shall run with the land and the Covenanter(s) further agrees that whenever the property shall be held, sold and conveyed, it shall be subject to

the covenants, stipulations, agreements and provisions of this Declaration, which shall apply to, bind and be obligatory upon the Covenanter(s) hereto, its heirs, successors and assigns and shall bind all present and subsequent owners of the property served by the facility.

7. The Covenanter(s) shall promptly notify the City when the Covenanter(s) legally transfers any of the Covenanter(s) responsibilities for the facility. The Covenanter(s) shall supply the City with a copy of any document of transfer, executed by both parties.

8. The provisions of this Declaration shall be severable and if any phrase, clause, sentence or provisions is declared unconstitutional, or the applicability thereof to the Covenanter is held invalid, the remainder of this Covenant shall not be affected thereby.

9. The Declaration shall be recorded among the Land Records of (Governing Body) at the Covenanter(s) expense.

10. In the event that the City shall determine at its sole discretion at future time that the facility is no longer required, then the City shall at the request of the Covenanter(s) execute a release of this Declaration of Covenants which the Covenanter(s) shall record at its expenses

IN WITNESS WHEREOF, the Covenanter(s) have executed
this Declaration of Covenants as of this_______day
of____________________, 20_____.
ATTEST: FOR THE COVENANTOR(S)
__________________________ __________________________
(Signature) (Signature)
__________________________ __________________________
(Printed Name) (Printed Name and Title)

STATE OF______________________ :
COUNTY OF ___________________ :
On this________day of______________, 20___, before me,
the undersigned officer, a Notary Public in and for the State and
County aforesaid, personally appeared __________________________,
who acknowledged himself to be__________________________,
of____________________________, and he as such authorized to do
so, executed the foregoing instrument for the purposes therein contained
by signing his name as____________________________for
said________________________________.
WITNESS my hand and Notaries Seal
My commission expires_________________ __________________
Notary Public
Seen and approved
____
City of Ormond Beach

Project Name:
City of Ormond Beach LID Plan Number:
Maintenance Requirements and Schedule
Site IMP ID
Basin
IMP type

Required Maintenance Inspetions and Activities

1	
2	
3	
4	
5	
6	
7	
8	
9	Annual Recertification /Inspection by Professional Engineer.

Maintenance Schedule

Month	Inspection and Maintenance Activities Required								
	1	2	3	4	5	6	7	8	9
January									
February									
March									
April							M		M
May									
June									
July									
August									
September									
October									
November									
December									

Legend:
X - As Needed During the Month(s) Noted
M -Monthly During the Month(s) Noted
W - Weekly During the Month(s) Noted
B - Bi-weekly During the Month(s) Noted
Y - Annualy during Month Noted
1Y During First year Only
2Y - Biennially, (Even numbered Years)

Project Name:
City of Ormond Beach LID Plan Number:
Maintenance Requirements and Schedule
Site IMP ID
Basin
IMP type

Certification of System Compliance

I Certify that for the Integrated Management Practice (IMP) noted as IMP on the plans prepared for th PROJECT NAME site, I or someone under my direction have inspected and found the IMP to be operational; I have noted any deficiencies that have been corrected in the space below. To the best of my determinaiton, the required maintenance activities have been performed in order to ensure proper perfomance of the system; this schedule has been reviewed with the maintenance entity for this property,with emphasis placed upon their role in the continued success of this IMP and the LID plan for this site.

Notes / Deficienies:

____

____

____

Certified by:

Name(Printed)	Signature
Organization	Florida Registration Number
Address	Date
City, State, Zip Code	
Telephone Number	

Note: This certification, accompanied by any relevant support data should be submitted to

LID Administrator
Planning Department
City of Ormond Beach
Room 104
Ormond Beach, Florida 32174

No later than April 30 of each year reflecting the twelve months prior to the certification, and any preparations required to prepare the site and its IMPs for the heavy reain season.

Project Name:
City of Ormond Beach LID Plan Number:
Maintenance Requirements and Schedule
Site IMP ID
Basin
IMP type Bioretention

Required Maintenance Inspections and Activities

1	Irrigate to promote growth, survival, and proper functioning of system.
2	Prune and Weed to maintain appearance.
3	Remove accumulated trash and debris
4	Replace mulch; inspect gravel, stone and other groundcover replacing as needed.
5	Inspect inflow area for sediment accumulation; remove any accumulated sediment and debris
6	Inspect area for erosion, and formation of ruts, gullies, and washouts; plant replacement vegetation in eroded areas.
7	Inspect for dead or dying vegetation, remove dead material and plant replacement vegetation as needed.
8	Annual Recertification /Inspection by Professional Engineer.

Maintenance Schedule

Month	1	2	3	4	5	6	7	8	
January	X	M	B						
February	X	M	B						
March	X	M	B	Y	Y	Y	Y		
April	X	M	B					Y	
May	X	M	B						
June	X	M	B						
July	X	M	B						
August	X	M	B						
September	X	M	B		1Y	1Y	1Y		
October	X	M	B						
November	X	M	B						
December	X	M	B						

Legend:
X - As Needed During the Month(s) Noted
M -Monthly During the Month(s) Noted
W - Weekly During the Month(s) Noted
B - Bi-weekly During the Month(s) Noted
Y - Annually during Month Noted
1Y During First year Only
2Y - Biennially, (Even numbered Years)

Project Name:
City of Ormond Beach LID Plan Number:
Maintenance Requirements and Schedule
Site IMP ID
Basin
IMP type Bioretention

Certification of System Compliance

I Certify that for the Integrated Management Practice (IMP) noted as IMP on the plans prepared for th PROJECT NAME site, I or someone under my that have been corrected in the space below. To the best of my determination, the required maintenance activities have been performed in order to ensure proper performance of the system; this schedule has been reviewed with the maintenance entity for this property, with emphasis placed upon their role in the continued success of this IMP and the LID plan for this site.

Notes / Deficiencies:

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Certified by:

Name(Printed)	Signature
Organization	Florida Registration Number
Address	Date
City, State, Zip Code	
Telephone Number	

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LID Administrator
Planning Department
City of Ormond Beach
Room 104
Ormond Beach, Florida 32174

No later than April 30 of each year reflecting the twelve months prior to the certification, and any preparations required to prepare the site and its IMPs for the heavy rain season.

Project Name:
City of Ormond Beach LID Plan Number:
Maintenance Requirements and Schedule
Site IMP ID
Basin
IMP type Rain Garden

Required Maintenance Inspections and Activities

1	Irrigate to promote growth, survival, and proper functioning of system.
2	Prune and Weed to maintain appearance.
3	Remove accumulated trash and debris
4	Replace mulch; inspect gravel, stone and other groundcover replacing as needed.
5	Inspect inflow area for sediment accumulation; remove any accumulated sediment and debris
6	Inspect area for erosion, and formation of ruts, gullies, and washouts; plant replacement vegetation in eroded areas.
7	Inspect for dead or dying vegetation, remove dead material and plant replacement vegetation as needed.
8	Annual Recertification /Inspection by Professional Engineer.

Maintenance Schedule

Month	1	2	3	4	5	6	7	8	
January	X	M	B						
February	X	M	B						
March	X	M	B	Y	Y	Y	Y		
April	X	M	B					Y	
May	X	M	B						
June	X	M	B						
July	X	M	B						
August	X	M	B						
September	X	M	B		1Y	1Y	1Y		
October	X	M	B						
November	X	M	B						
December	X	M	B						

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1Y During First year Only
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Project Name:
City of Ormond Beach LID Plan Number:
Maintenance Requirements and Schedule
Site IMP ID
Basin
IMP type Rain Garden

Certification of System Compliance

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Project Name:	
City of Ormond Beach LID Plan Number:	
Maintenance Requirements and Schedule	
Site IMP ID	
Basin	
IMP type	Rainwater Harvest

Required Maintenance Inspections and Activities

1 Inspect storage tank screens and pretreatment devices. Clean as needed.

2 Inspect gutters and downspouts. Remove any accumulated leaves and debris.

3 Clean storage tank screens.

4 Inspect pretreatment devices for sediment accumulation. Remove trash and debris

5 Inspect storage tank for algal blooms. Treat as necessary.

6 Inspect overflow areas for erosion and the formation of ruts, gullies, and washouts. Stabilize eroded areas with appropriate vegetation as necessary.

7 If system includes pumping component; inspect pumps, electric connection, valves, solenoids, actuators, and level switches.

8 Annual Recertification /Inspection by Professional Engineer.

Maintenance Schedule

Month	Inspection and Maintenance Activities Required								
	1	2	3	4	5	6	7	8	9
January	M								
February	M								
March	M	Y	Y	Y	Y	Y	Y - X		
April	M							Y	
May	M								
June	M								
July	M								
August	M								
September	M	1Y	1Y	1Y	1Y	1Y	1Y		
October	M								
November	M								
December	M								

Legend:

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B - Bi-weekly During the Month(s) Noted
Y - Annually during Month Noted
1Y During First year Only
2Y - Biennially, (Even numbered Years)

Project Name:
City of Ormond Beach LID Plan Number:
Maintenance Requirements and Schedule
Site IMP ID
Basin
IMP type Rainwater Harvest

Certification of System Compliance

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Project Name:
City of Ormond Beach LID Plan Number:
Maintenance Requirements and Schedule
Site IMP ID
Basin
IMP type Disconnect

Required Maintenance Inspections and Activities

1	Inspect and remove trash, siltation and debris from downspout outlet.
2	Inspect flow path to ensure that runoff routing is free from obstructions
3	Mow sodded areas
4	Annual Recertification /Inspection by Professional Engineer.

Maintenance Schedule

Month	Inspection and Maintenance Activities Required			
	1	2	3	4
January	M	X		
February	M	X		
March	M			
April	M		B	Y
May	M		B	
June	M		B	
July	M		B	
August	M		B	
September	M		B	
October	M		B	
November	M	X		
December	M	X		

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Project Name:
City of Ormond Beach LID Plan Number:
Maintenance Requirements and Schedule
Site IMP ID
Basin
IMP type Disconnect

Certification of System Compliance

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Project Name:

City of Ormond Beach LID Plan Number:

Maintenance Requirements and Schedule

Site IMP ID

Basin

IMP type: Vegetative Filter Strip

Required Maintenance Inspections and Activities

1	
2	
3	
4	
5	
6	
7	
8	
9	Annual Recertification /Inspection by Professional Engineer.

Maintenance Schedule

Month	Inspection and Maintenance Activities Required								
	1	2	3	4	5	6	7	8	9
January									
February									
March									
April							M		M
May									
June									
July									
August									
September									
October									
November									
December									

Legend:

X - As Needed During the Month(s) Noted
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Project Name:
City of Ormond Beach LID Plan Number:
Maintenance Requirements and Schedule
Site IMP ID
Basin
IMP type Vegetative Filter Strip

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Project Name:
City of Ormond Beach LID Plan Number:
Maintenance Requirements and Schedule
Site IMP ID
Basin
IMP type Grassed Swales

Required Maintenance Inspections and Activities

1	Inspect swale, slopes, check dams, inlets and outlets for vegetative coverage, erosion, ponding, or dead grass.
2	Add reinforcement planting to maintain 90% turf cover.
3	Check inflow points, outlet, and at check dams for sedimentation, debris, and trash. Remove as needed.
4	Look for any bare soil or sediment sources in the contributing drainage basin, stabilize immediately.
5	Mow Grassed Swale.
6	Annual Recertification /Inspection by Professional Engineer.

Maintenance Schedule

Month	Inspection and Maintenance Activities Required					
	1	2	3	4	5	6
January			M		M	
February			M		M	
March	M	X	M	M	B	
April	M	X	B	M	B	Y
May	M	X	B	M	B	
June	M		B	M	B	
July	M		B	M	B	
August	M		B	M	B	
September	M		B	M	B	
October	M		M	M	M	
November			M		M	
December			M		M	

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1Y During First year Only
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Project Name:
City of Ormond Beach LID Plan Number:
Maintenance Requirements and Schedule
Site IMP ID
Basin
IMP type Grassed Swales

Certification of System Compliance

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Project Name:
City of Ormond Beach LID Plan Number:
Maintenance Requirements and Schedule
Site IMP ID
Basin
IMP type Infiltration Trench

Required Maintenance Inspections and Activities

1	Inspect for accumulated sediment, trash, and debris; remove as necessary.
2	Inspect area for erosion, and formation of ruts, gullies, amd washouts; plant replacement vegetation in eroded areas.
3	Irrigate to promote growth, survival, and proper functioning of system.
4	Inspect pretreatment devices for sediment accumulation. Remove accumulated trash and debris.
5	Inspect top layer of filter fabric and pea gravel for sediment accumulation. Remove and replace as necessary.
6	Inspect for damage, paying particular attention to inlets, outlets, and overflow devices; repair or replace damaged components as necessary.
7	Test infiltration rate ensuring system recovers at a rate not to exceed 72 hours. Longer recovery times indicates failure of system
8	Perform total rehabilitation of the infiltration practice removing stone or bed and excavating clean soil on the sides and bottoms of the IMP.
9	Annual Recertification /Inspection by Professional Engineer.

Maintenance Schedule

Month	Inspection and Maintenance Activities Required								
	1	2	3	4	5	6	7	8	9
January	M	M	X					U	
February	M	M	X					P	
March	M	M	X	Y	Y	Y	Y	O	
April	M	M	X					N	Y
May	M	M	X						
June	M	M	X					F	
July	M	M	X					A	
August	M	M	X					I	
September	M	M	X	1Y	1Y			L	
October	M	M	X					U	
November	M	M	X					R	
December	M	M	X					E	

Legend:
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1Y During First year Only
2Y - Biennially, (Even numbered Years)

Project Name:
City of Ormond Beach LID Plan Number:
Maintenance Requirements and Schedule
Site IMP ID
Basin
IMP type Infiltration Trench

Certification of System Compliance

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Notes / Deficiencies:

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Project Name:
City of Ormond Beach LID Plan Number:
Maintenance Requirements and Schedule
Site IMP ID
Basin
IMP type Level Spreader

Required Maintenance Inspections and Activities

1 Inspect diverter device, clean and make repairs.
2 Inspect the level spreader for trash, debris, and sediment removing as necessary.
3 Inspect area downstream of level spreader for erosion, and formation of ruts, gullies, and washouts; plant replacement vegetation in eroded areas.
4 Inspect for stone washout from level spreader; replace as necessary.
5 Inspect for settlement of level spreader (no longer level); add stone to level.
6 Remove any weeds, or other vegetation growing on level spreader or in diversion swale.
7 Annual Recertification /Inspection by Professional Engineer.

Maintenance Schedule

Month	Inspection and Maintenance Activities Required								
	1	2	3	4	5	6	7		
January	M	M		M					
February	M	M							
March	M	M	Y	M	Y	Y			
April	M	M					Y		
May	M	M		M					
June	M	M							
July	M	M		M					
August	M	M							
September	M	M		M	1Y	1Y			
October	M	M							
November	M	M		M					
December	M	M							

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Project Name:
City of Ormond Beach LID Plan Number:
Maintenance Requirements and Schedule
Site IMP ID
Basin
IMP type Level Spreader

Certification of System Compliance

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Project Name:
City of Ormond Beach LID Plan Number:
Maintenance Requirements and Schedule
Site IMP ID
Basin
IMP type: Permeable Pavement/Pavers

Required Maintenance Inspections and Activities

1	Inspect surface for debris and sediment, remove as necessary.
2	Check surface for excessive ponding; repair as needed.
3	Inspect for dead or dying vegetation; take appropriate remedial action.
4	Vacuum Sweep permeable pavement to keep surface free of sediment
5	High pressure hose washing of surface pores
6	Inspect pavement for excessive raveling, potholes, wide cracking, spot repair areas where surface area is than ten percent of total.
7	Test permeability at installed infiltration test locations.
8	Annual Recertification /Inspection by Professional Engineer.
9	Rehabilitate failed permeable pavement system including surface course and stone reservoir layer.

Maintenance Schedule

Month	Inspection and Maintenance Activities Required								
	1	2	3	4	5	6	7	8	9
January	M	M	M	M	M				U
February	M	M	M						P
March	M	M	M			Y	2Y	Y	O
April	M	M	M	M	M				N
May	M	M	M						
June	M	M	M						F
July	M	M	M	M	M				A
August	M	M	M						I
September	M	M	M						L
October	M	M	M	M	M				U
November	M	M	M						R
December	M	M	M						E

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Project Name:
City of Ormond Beach LID Plan Number:
Maintenance Requirements and Schedule
Site IMP ID
Basin
IMP type Permeable Pavement/Pavers

Certification of System Compliance

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Project Name:
City of Ormond Beach LID Plan Number:
Maintenance Requirements and Schedule
Site IMP ID
Basin
IMP type Reforestation

Required Maintenance Inspections and Activities

1	Water plants to promote growth and survival
2	Inspect reforested / revegetated areas for erosion following rainfall events. Plant additional material in eroded areas.
3	Inspect reforested/revegetated areas for dead or dying vegetation. Plant replacement material as needed.
4	Inspect / prune and care for individual trees and shrubs as necessary.
5	Annual Recertification /Inspection by Professional Engineer.

Maintenance Schedule

Month	Inspection and Maintenance Activities Required				
	1	2	3	4	5
January	X(1Y)	X(1Y)			
February	X(1Y)	X(1Y)			
March	X(1Y)	X(1Y)	M	M	
April	X	B	M	B	M
May	X	B	M	B	
June	X	B	M	B	
July	X	B	M	B	
August	X	B	M	B	
September	X	B	M	B	
October	X(1Y)	X(1Y)	M	M	
November	X(1Y)	X(1Y)			
December	X(1Y)	X(1Y)			

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W - Weekly During the Month(s) Noted
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Project Name:
City of Ormond Beach LID Plan Number:
Maintenance Requirements and Schedule
Site IMP ID
Basin
IMP type Reforestation

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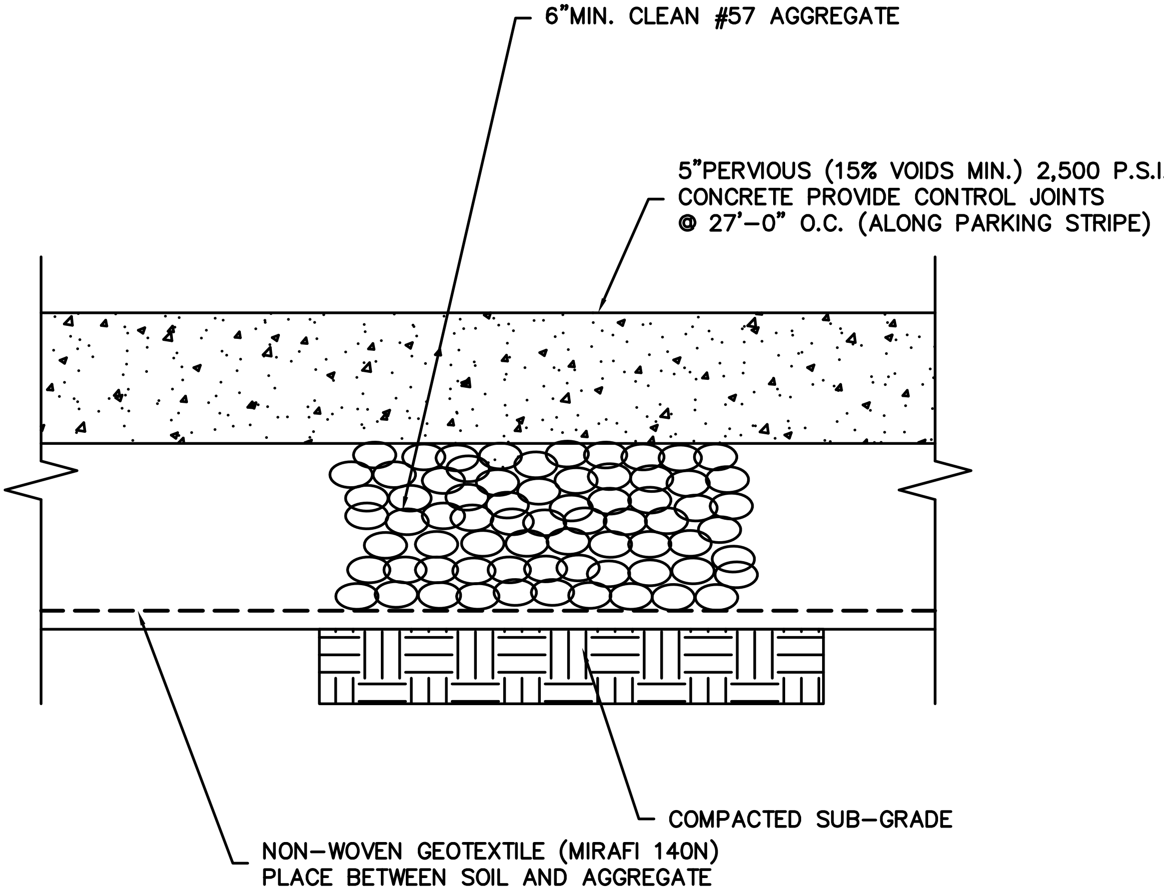
Appendix 'C'
Standard Details



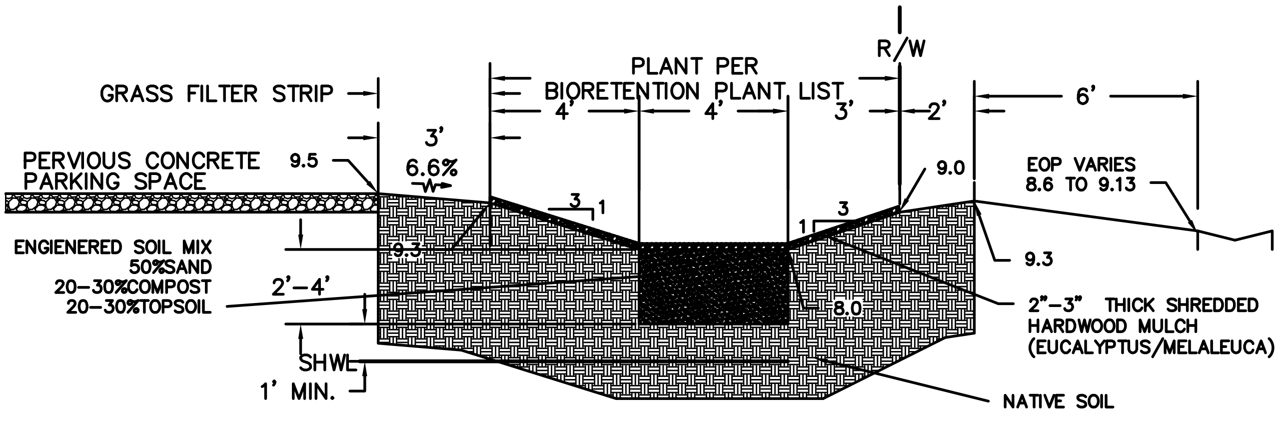
PERVIOUS CONCRETE PAVEMENT SECTION

SEE SPECIFICATIONS AND SOIL REPORT FOR ADDITIONAL INFORMATION

PERVIOUS CONCRETE MAINTENANCE REQUIREMENTS

1. THE OWNER IS RESPONSIBLE FOR INSPECING THE PERVIOUS CONCRETE TO VERIFY THAT IT IS FUNCTIONING AS DESIGNED AND THAT THE VOIDS IN THE CONCRETE HAVE NOT BECOME CLOGGED WITH DEBRIS.
2. THE OWNER SHALL REQUIRE THE LANDSCAPE CONTRACTOR TO KEEP THE PERVIOUS CONCRETE FREE OF MULCH, GRASS CLIPPINGS, AND OTHER DEBRIS THAT COULD POTENTIALLY FILL THE VOIDS IN THE CONCRETE. THE LANDSCAPE CONTRACTOR SHALL ALSO POWER BLOW THE AREA AFTER EVERY MOWING.
3. THE OWNER SHALL PRESSURE WASH THE PERVIOUS AREA AS NEEDED TO RESTORETHE PERMEABILITY AT LEAST ONCE A YEAR.

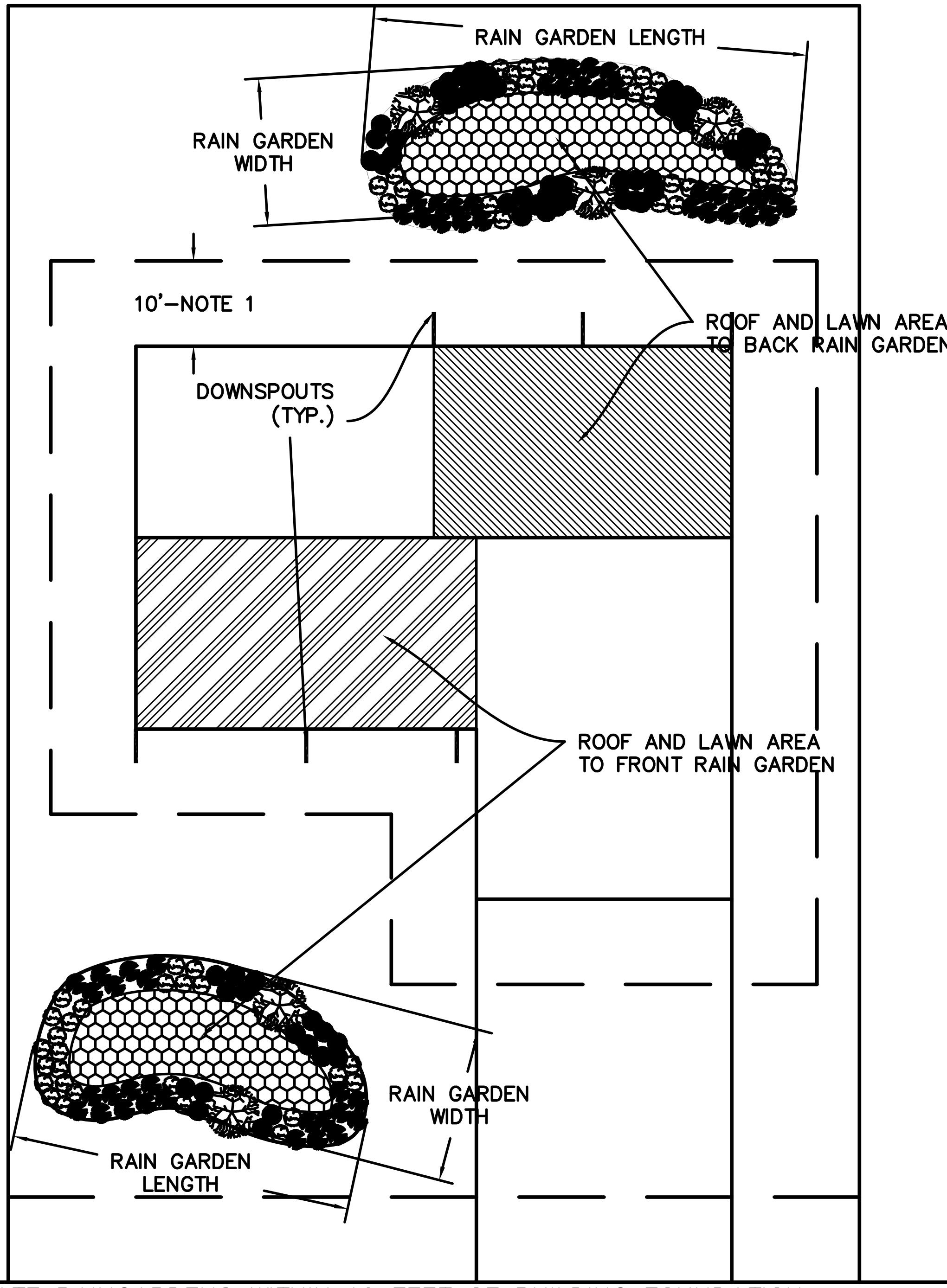
CITY OF ORMOND BEACH ★ FLORIDA ★	LOW IMPACT DEVELOPMENT (LID) CONSTRUCTION DETAIL PERVIOUS CONCRETE PAVEMENT	INDEX LID–1 FEB 2013



BIORETENTION AREA SECTION

SCALE: 1" = 5'

	LOW IMPACT DEVELOPMENT (LID) CONSTRUCTION DETAIL BIORETENTION AREA	INDEX LID-2 FEB 2013



NOTES:

1. DO NOT LOCATE RAINGARDENS WITHIN 10 FEET OF BUILDING FOUNDATION.
2. ENSURE THAT RAINGARDEN IS PROPERLY SIZED.
3. LOCATED RAINGARDENS IN (NATURAL) LOW SPOUTS, AS POSSIBLE.
4. PLACE RAINGARDENS IN LOCATIONS THAT ALLOW FOR DRAINAGE TO EASILY TRAVEL TO RAINGARDEN AS WELL AS ALLOWING FOR OVERFLOW OF RUNOFF DOWNSTREAM DURING PERIODS OF EXTREME RAINFALL.
5. AVOID CREATING TRIP HAZARDS AND IMPEDING THE FUNCTIONAL USE OF THE PROPERTY.

CITY OF ORMOND BEACH ★ FLORIDA ★	LOW IMPACT DEVELOPMENT (LID) CONSTRUCTION DETAIL RAINGARDEN DETAIL (1/2) – LAYOUT	INDEX LID–3 FEB 2013

LOW IMPACT DEVELOPMENT (LID)
CONSTRUCTION DETAIL

RAINGARDEN DETAIL (2/2) – SCHEMATIC

INDEX
LID–4
FEB 2013

BIORETENTION / RAIN GARDEN PLANT SELECTION LIST

Wildflowers, Ferns, Grasses, and Sedges:

1. *Asclepias incarnata,* Swamp Milkweed
2. *Canna flaccida,* Golden canna
3. *Pontederia cordata,* Pickerel Weed
4. *Eupatorium coelestinum,* Blue mistflower
5. *Helenium pinnatifidum,* Everglades daisy
6. *Lobelia glandulosa,* Glades lobelia
7. *Sabatia* spp., Marsh pinks
8. *Acrostichum danaefolium,* Leather fern
9. *Osmunda regalis* var. *spectabilis,* Royal fern
10. *Thelypterispalustris,* Marsh fern
11. *Woodwardia virginica,* Virginia chain fern
12. *Muhlenbergia capillaris,* Gulf muhly grass
13. *Aster carolinianus,* Climbing aster
14. *Asclepias tuberosa*, Butterfly weed
15. *Iris virginica*, Blue flag iris
16. *Coreopsis lanceolata,* Tickseed
17. *Spartina bakeri*, Cordgrass
18. *Muhlenbergia capillaries,* Muhly grass
19. *Osmunda cinnamomea*, Cinnamon Fern
20. *Chasmanthium latifolium,* River Oats
21. *Osmunda regalis*, Royal Fern
22. *Hibiscus coccineus*, Scarlet Hibiscus
23. *Rudbeckia hirta*, Rudbeckia
24. *Veronia gigantea*, Ironweed
25. *Solidago sp*, Goldenrod

Trees and Shrubs:

1. *Acer rubrum* var. *trilobum,* Red maple
2. *Annona glabra,* Pond apple
3. *Betula nigra,* River birch
4. *Cephalanthus occidentalis,* buttonbush
5. *Chrysobalanus icaco,* Cocoplum
6. *Gordonia lasianthus,* Loblolly bay
7. *Hibiscus grandiflorus* Swamp Hibiscus
8. *Ilex cassine,* Dahoon holly
9. *Ilex glabra,* Galberry
10. *Ilex vomitoria,* Yaupon Holly
11. *Itea virginica,* Virginia Willow
12. *Magnolia virginiana,* Sweetbay magnolia
13. *Myrica cerifera,* Wax myrtle
14. *Myrsine floridana,* Myrsine
15. *Nyssa sylatica,* Black gum
16. *Pinus palustris,* Longleaf pine
17. *Sabal palmetto,* Cabbage palm
18. *Sabal minor,* Dwarf palmetto
19. *Salix caroliniana,* Coastal plain willow
20. *Sambucus canadensis,* American elderberry
21. *Serenoa repens,* Saw palmetto
22. *Styrax americana,* snowbell
23. *Taxodium ascendens,* Pond cypress
24. *Taxodium distichum,* Bald cypress
25. *Viburnum obovatum*, Walter's Viburnum

CITY OF ORMOND BEACH ★ FLORIDA ★	LOW IMPACT DEVELOPMENT (LID) CONSTRUCTION DETAIL BIORETENTION / RAIN GARDEN PLANT LIST	INDEX LID-5 FEB 2013

BIORETENTION / RAIN GARDEN PLANT SELECTION LIST

Wildflowers, Ferns, Grasses, and Sedges:

1. *Asclepias incarnata,* Swamp Milkweed
2. *Canna flaccida,* Golden canna
3. *Pontederia cordata,* Pickerel Weed
4. *Eupatorium coelestinum,* Blue mistflower
5. *Helenium pinnatifidum,* Everglades daisy
6. *Lobelia glandulosa,* Glades lobelia
7. *Sabatia* spp., Marsh pinks
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