South Burlington
Stormwater Utility

Low Impact Development Guidance Manual

May 2009

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SECTION 1

INTRODUCTION

INTRODUCTION

Overview

Low Impact Development (LID) practices are a set of site development techniques designed to reduce the amount of stormwater runoff and associated pollutants leaving a site. LID practices reduce the impact of development on natural water resources by mimicking existing drainage patterns and retaining stormwater runoff onsite, commonly allowing for infiltration of precipitation into the underlying soil media. Successful implementation of LID strategies will reduce the total volume and peak flow rates of stormwater runoff generated at a site. It can also reduce the need for traditional stormwater treatment facilities (e.g. stormwater detention ponds). LID practices are typically small in scale and dispersed throughout a development site to provide stormwater treatment near the area of runoff generation. These techniques are generally applicable on residential, commercial, industrial and institutional development projects.

The construction of impervious surface area and associated stormwater drainage infrastructure alters natural drainage patterns and can have a significant impact on receiving streams due to increased runoff volumes, flow rates and pollutant loading. Based on the percent of impervious surface area at a site, the annual volume of stormwater runoff can increase up to 16 times the predevelopment rate, with proportional reductions in groundwater recharge.[1] Impervious surfaces accumulate pollutants deposited from the atmosphere, leaked from vehicles, or windblown in from adjacent areas. During storm events, these pollutants quickly wash off, and are rapidly delivered to downstream waters. Furthermore, increasing stormwater runoff rates and discharge velocities commonly result in stream bank erosion, incised channels and downstream flooding.

Source: www.co.monroe.in.us

Sediment laden stormwater can physically alter stream habitat and can result in the smothering of critical voids located at the bottom of stream channels. Turbidity can reduce the amount of light that reaches aquatic vegetation and can also increase water temperatures. In addition to sediment, stormwater commonly carries a broad mix of toxic chemicals, bacteria, metals, oil and grease to nearby receiving streams.

Rather than relying on traditional stormwater management practices that are costly to construct and often consume valuable land, LID practices utilize small-scale treatment systems and techniques to treat and infiltrate stormwater runoff onsite and reduce the total amount of stormwater generated, thereby promoting hydrologic characteristics similar to

[1] Schueler, T., The Importance of Imperviousness, Watershed Protection Techniques, 1994, 1(3)-100-111

pre-development conditions. Terms such as green infrastructure, conservation design, and sustainable stormwater management are often used synonymously with LID practices. All of these concepts support the use of small-scale, localized facilities that often incorporate the use of vegetation, open space and other natural processes to provide for infiltration and subsequent stormwater volume, flow rate and pollutant loading reductions.

The purpose of this manual is to provide general guidance on a set of common LID practices and associated goals and objectives. The intended audience of this guidance manual is homeowners, business owners, developers, and designers. The fact sheets that are presented herein provide an overview of specific LID strategies including; practice definition, purpose, applicability, and design and maintenance considerations. This information should be utilized to educate and screen various LID practices based on site specific characteristics and objectives for both new and redevelopment projects.

DEFINITIONS

Best Management Practice (BMP): Schedules of activities, prohibitions of practices, general good house keeping practices, pollution prevention and educational practices, maintenance procedures, and other management practices to prevent or reduce the discharge of pollutants directly or indirectly to the stormwater system or waters of the State of Vermont or the United States. BMPs also include treatment practices, operating procedures, and practices to control site runoff, spillage or leaks, sludge or water disposal, or drainage from raw materials storage.

Hot Spot: Area where land use or activities generate highly contaminated runoff, with concentrations of pollutants in excess of those typically found in stormwater.

Impervious Surface: Those manmade surfaces, including, but not limited to, paved and unpaved roads, parking areas, roofs, driveways, and walkways, from which precipitation runs off rather than infiltrates. For the purpose of this manual, impervious surface shall also include, but is not limited to, compacted gravel or soil surfaces, storage areas, awnings, and other fabric or plastic coverings.

Low Impact Development (LID): A stormwater management strategy that is used to reduce stormwater runoff volumes, rates and pollutant loading by managing the runoff as close to the source as possible using non-structural practices to mimic the pre-existing hydrologic conditions.

Stormwater Treatment Practice (STP): A stormwater treatment practice is a specific device or technique designed to provide stormwater quality treatment and/or quantity control.

Stormwater: Stormwater is rainfall runoff, snowmelt runoff, surface runoff and general drainage related to a precipitation event.

Suspended Sediment: Solid material (e.g., sand, silt, etc.) that is in suspension and is being transported by water from its site of origin.

Time of Concentration (Tc): Time required for water to flow from the most hydraulically remote point of a watershed to the outlet.

SECTION 2

CONSERVATION DESIGN PRACTICES

CLUSTER DEVELOPMENT

Definition
Cluster development is a low impact development (LID) practice that promotes the construction of buildings concentrated in specific areas to minimize land development impacts and preserve open space. The preservation of open space associated with cluster development can provide recreational opportunities, reduce air pollution, attenuate noise, moderate temperatures and preserve environmentally sensitive features such as wetlands, floodplains and prime agricultural lands.

Purpose
The purpose of cluster development is to reduce the overall footprint of land development projects thereby preserving existing open space areas. Relatively high development densities are encouraged which results in the reduction of infrastructure requirements and associated impervious cover. Less impervious coverage results in a reduction in stormwater runoff volumes, flow rates and suspended pollutants draining from a site and reduces the burden on downstream stormwater infrastructure. The preservation of vegetated open space allows for the treatment and infiltration of stormwater runoff. The reduction of infrastructure associated with cluster development also results in lower construction and maintenance costs.

Source: www.pedbikeimages.org/Dan Burden

Conditions Where Practice Applies
Cluster development opportunities are commonly associated with new residential developments and promoted within municipal ordinances. Developers are often allowed to increase the density of a development if cluster development practices, such as preserved open space corridors, are incorporated into the site design.
To the extent practicable, preserved open areas should be delineated to maximize contiguous land and avoid fragmentation. Efforts should be taken to preserve viewsheds and incorporate critical site features such as wetlands and floodplains into the conserved area.

Design Criteria
Opportunities for implementing cluster development strategies are based on site specific factors such as; land availability, allowable development density, natural topography and general site layout. Design consideration should also be given to provide pedestrian pathways, bikeways and common areas for shared community use. Disturbance to proposed open space areas should be minimized during construction activities. The limits of all open areas should be clearly shown on all construction drawings and identified onsite prior to construction to prevent inadvertent disturbance. Open space areas should be formalized through establishment of a conservation easement or other formal documentation process, as applicable. Although, the Vermont Stormwater Management

Manual (VSWMM) does not provide specific guidance on cluster development, it does provide a detailed description of natural area conservation methods.

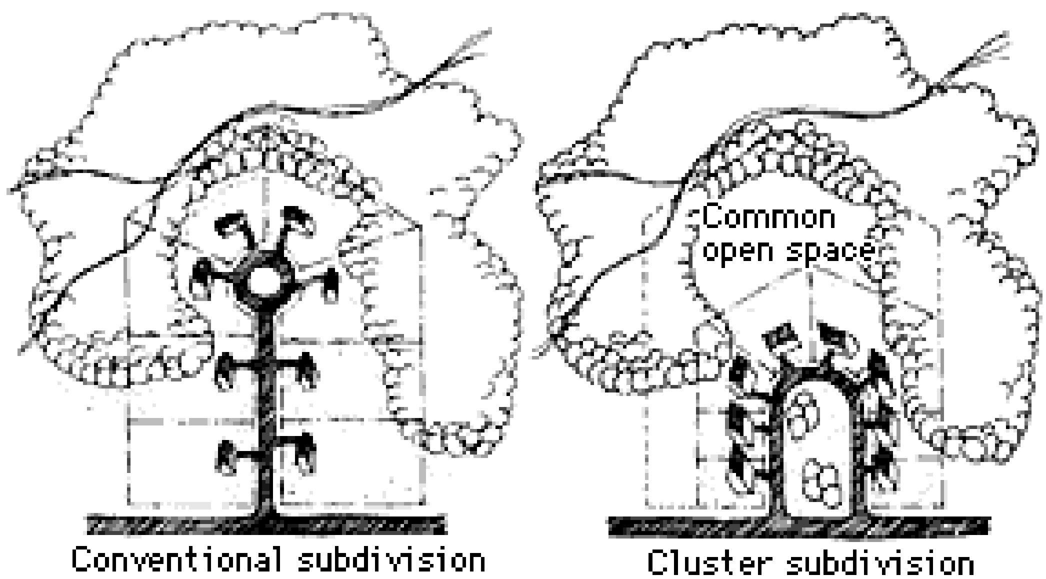
Maintenance

There are no formal maintenance requirements associated with the cluster development LID strategy. Proposed open space areas should be maintained in a vegetative state and restricted from development and disturbance. The maintenance and oversight of open space areas may require the formation of a homeowners association and the assessment of maintenance fees.

Plans & Specifications

Plans & specifications for cluster development shall be in accordance with this guidance document, local land development regulations and the Vermont Stormwater Management Manual, as applicable. At a minimum, the following information should be submitted:

1. A site plan that identifies the proposed cluster development layout and density, open space boundaries and stormwater management system
2. Construction details (as applicable)
3. Conservation easement or other formal documentation for conserved open space areas (as applicable)



Source: www.extension.umn.edu/distribution/naturalresources/dd7059.html

MINIMIZE PAVEMENT WIDTHS

Definition

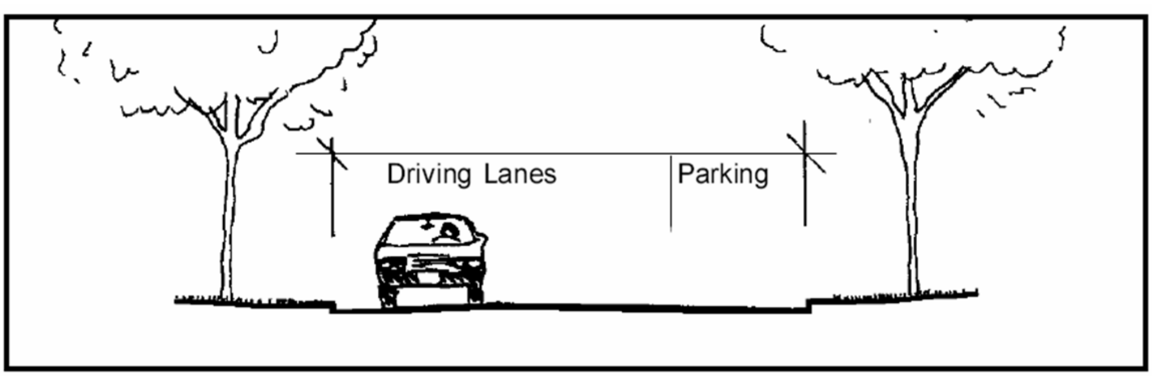
The reduction of roadway pavement widths is a low impact development (LID) practice that reduces the total amount of impervious area associated with land development projects. This practice promotes the design of roadways with minimum pavement widths to support local traffic and parking demands, as well as emergency and maintenance vehicles. Reduced roadway widths result in an increase in pervious area and a subsequent reduction in the generation of stormwater runoff and associated stormwater management infrastructure.

Purpose

The purpose of reducing pavement widths is to reduce impervious coverage while providing safe and adequate vehicular access. Historically, many roadways have been constructed wider than necessary. Less impervious coverage results in a reduction in stormwater runoff volumes, flow rates and suspended pollutants draining from a site and reduces the burden on downstream stormwater infrastructure. Precipitation that falls or melts on pervious areas typically infiltrates into the underlying soil media thereby recharging groundwater supplies and reducing runoff. Other benefits of reduced roadway widths include; lower construction and maintenance costs and a perceived traffic calming effect resulting in a more pedestrian friendly development.

Conditions Where Practice Applies

Opportunities to reduce roadway pavement widths are commonly associated with new residential developments. A popular approach for reducing residential roadway widths is to provide for parking on only one side of the street. Based on local traffic demands, the radius of cul-de-sacs can be reduced and sidewalks may be constructed on only one side of residential streets, thereby further reducing impervious surface coverage. In addition, site designers should consider limiting the width of residential driveways where applicable. The reduction of pavement widths and reclamation of existing impervious area may also be implemented through site redevelopment projects.



Source: Valley Branch Watershed District, 2000

Design Criteria

All roadways shall be designed and constructed to provide safe and adequate vehicular access. Opportunities for implementing reduced roadway and driveway widths are based on site specific factors such as; anticipated vehicular traffic, on-street parking demands, development density and site layout. Design consideration should also be given to emergency and maintenance vehicle access, travel speeds, turning radii, visual site distances and traffic circulation.

Maintenance

There are no formal maintenance requirements associated with the reduced roadway width LID strategy. Periodic street sweeping and visual roadway inspection should be ongoing for all roadways.

Plans & Specifications

Plans & specifications for reduced pavement widths shall be in accordance with this guidance document and local land development regulations. At a minimum, the following information should be submitted:

1. A site plan that identifies the areas of reduced pavement widths
2. Construction details
3. Anticipated traffic and on-street parking demand estimates

MINIMIZE SETBACKS & FRONTAGES

Definition

The reduction of setbacks and frontages is a low impact development (LID) practice that reduces the total amount of impervious area associated with land development projects. Reduced setbacks result in structures located closer to the street, thereby effectively reducing the length of driveway needed to adequately access the site. Similarly, reduced frontage widths results in structures located closer together, ultimately requiring less public infrastructure, such as roadway and utilities. Implementation of reduced setbacks and frontages promotes open space preservation and associated onsite stormwater infiltration.

Purpose

The purpose of reducing setbacks and frontages is to achieve desired development densities while minimizing the need for associated infrastructure such as driveways, roadways, and utilities. The reduction of impervious infrastructure results in decreased stormwater runoff volumes, flow rates and pollutant loading. In addition, use of these practices commonly reduces costs associated with construction and maintenance. Precipitation that falls or melts on pervious areas typically infiltrates into the underlying soil media thereby recharging groundwater supplies and reducing runoff. A reduction in stormwater runoff volumes and flow rates reduces the burden on downstream drainage infrastructure and decreases the risk for surface flooding.

Source: Horsley Witten Group, Inc.

Conditions Where Practice Applies

Reduced setbacks and frontages are commonly associated with new residential developments and promoted within municipal ordinances. Residential developments that incorporate reduced setbacks and frontages often have increased access and proximity to communal open space and a strong sense of neighborhood community. Efforts should be taken to preserve open areas that maximize contiguous land and incorporate critical site features such as wetlands, floodplains and viewsheds where applicable.

Design Criteria

Opportunities for implementing reduced setbacks and frontages are based on site specific factors such as; allowable site dimensions and development density, available land, natural topography and general site layout. Design consideration should be given to onsite parking requirements, pedestrian access / sidewalks, and driveway widths. The limits of all proposed open areas should be clearly shown on construction drawings and identified onsite in order to minimize disturbance during construction activities.

Maintenance

There are no formal maintenance requirements associated with the reduced setback and frontage LID strategy. Any proposed open space areas should be maintained in a vegetative state and restricted from development and disturbance. Residential developments that incorporate reduced setbacks and frontages are often part of a homeowners association that maintains and oversees common areas and assesses an ongoing association fee.

Plans & Specifications

Plans & specifications for reduced setbacks and frontages shall be in accordance with this guidance document and local land development regulations. At a minimum, the following information should be submitted:

1. A site plan that identifies the proposed setbacks, frontages and development density
2. Anticipated parking demand estimates
3. Conservation easement or other formal documentation for conserved open space areas (as applicable)

OPEN SPACE PRESERVATION

Definition

Open space preservation is a low impact development (LID) practice that promotes the conservation of natural areas, to assist in maintaining pre-development hydrologic and water quality characteristics by allowing onsite infiltration. In addition, preservation of open space can reduce air pollution, attenuate noise, and provide erosion control. Examples of open space preservation include:

- Undisturbed natural areas
- Wetlands, floodplains, vernal pools and associated buffers
- Forest retention areas

Purpose

Open space preservation provides habitat for native vegetation which allows for the treatment and infiltration of stormwater. Suspended sediment and the attached pollutants in stormwater runoff are filtered out as it infiltrates into the underlying soil media. Open space preservation provides groundwater recharge, and reduces the generation of stormwater runoff from the site. Open space preservation also prevents flood damage, provides for critical environmental areas (e.g. wetlands), preserves places of natural beauty and reduces the need to construct new infrastructure.

Conditions Where Practice Applies

To the extent practicable, conservation areas should be delineated to maximize contiguous land and avoid fragmentation. Efforts should be taken to incorporate critical site features such as wetlands and floodplains into the conserved natural area. Conservation of open space, moreover, can take place on the site of a development, or in some instances may take place on a separate parcel if authorized by local and/or State regulations.

Source: City of Davis, California

Design Criteria

Proposed open space areas should not be disturbed during construction activities (i.e., cleared or graded, except for temporary disturbances for utility construction). The limits of all proposed conservation areas should be clearly shown on all construction drawings and identified onsite prior to construction to prevent inadvertent disturbance. Open space areas should be formalized through establishment of a conservation easement or other formal documentation process. The Vermont Stormwater Management Manual (VSWMM) provides a detailed description of natural area conservation methods.

Maintenance

There are no formal maintenance requirements associated with open space preservation. Proposed conservation areas must be maintained in the natural vegetative state and restricted from development and disturbance. Defined trails should not be mowed or cut into conserved open space areas in any manner.

Plans & Specifications

Plans & specifications for open space preservation shall be in accordance with this guidance document, local land development regulations and the Vermont Stormwater Management Manual. At a minimum, the following information should be submitted:

1. A site plan that identifies the open space preservation boundaries and construction disturbance limits
2. Conservation easement or other formal documentation for the conserved natural area

SHARED DRIVEWAY

Definition
The construction of shared driveways is a low impact development (LID) practice that reduces the total amount of impervious area at developed sites. A common driveway is constructed in order to provide access to multiple buildings rather than individual driveways for each structure. Shared driveways result in an increase in pervious area and a subsequent reduction in the generation of stormwater runoff from the site.

Purpose
The purpose of shared driveways is to reduce impervious coverage while providing adequate site access to adjacent properties. Less impervious coverage results in a reduction in stormwater runoff volumes, flow rates and suspended pollutants draining from a site and reduces the burden on downstream stormwater infrastructure. Precipitation that falls or melts on pervious areas typically infiltrates into the underlying soil media thereby recharging groundwater supplies and reducing runoff.

Conditions Where Practice Applies
Shared driveways are commonly applicable for residential development but could also be appropriate for other land uses such as commercial development depending on site layout and vehicular traffic patterns. This LID practice is particularly applicable to residential development due to relatively low traffic demands and high development density. Benefits of this strategy for residential developments include; larger pervious lawns, meadows, forests, and/or gardens and reduced construction and maintenance costs for driveways and downstream stormwater infrastructure.

Source: Horsley Witten Group, Inc.

Design Criteria
Shared driveways should be designed and constructed to provide adequate site access to all adjoining properties. Opportunities for implementing shared driveways are based on site specific factors such as; development density, site layout, parking requirements and anticipated vehicular traffic demands. Design consideration should be given to driveway width, turning radii, visual site distances and visitor parking.

Maintenance
There are no formal maintenance requirements associated with shared driveways. Adjacent landscaping should be maintained in order to prevent visual barriers that could result in accidental collisions. Also, agreements among adjacent property owners should be established so that maintenance and parking arrangements are fully understood and agreed to by the affected parties.

Plans & Specifications

Plans & specifications for shared driveways shall be in accordance with this guidance document and local land development regulations. At a minimum, the following information should be submitted:

1. A site plan that identifies the shared driveway limits
2. Proposed maintenance, parking and landscaping plans

SITE FINGERPRINTING

Definition

Site fingerprinting is a low impact development (LID) strategy that minimizes the total amount of disturbed area at development sites by limiting construction related activities to areas that will be used for structures, roads and other infrastructure. This practice assists in minimizing land development impacts on local surface waters both during and after construction. In addition, site fingerprinting promotes the conservation of environmentally sensitive natural areas. Site fingerprinting is also commonly referred to as minimal disturbance techniques.

Purpose

In order to reduce the total amount of disturbed area at development sites, the practice of site fingerprinting is commonly utilized in conjunction with other LID strategies such as; shared driveways, cluster development, reduced pavement widths, reduced setbacks and frontages and porous pavement. A reduction in disturbed, compacted and impervious area results in decreased stormwater runoff volumes, flow rates and pollutant transport. Undisturbed vegetated areas typically allow for the infiltration of precipitation thereby recharging groundwater supplies and reducing the generation of stormwater runoff. Site fingerprinting techniques can reduce the need for extensive erosion prevention and sediment control measures during construction and can also reduce the costs associated with site landscaping.

Conditions Where Practice Applies

The practice of site fingerprinting is commonly associated with new residential developments although it can be applicable to other land development projects (new and redevelopment) for commercial, institutional and industrial purposes. Development projects that incorporate site fingerprinting techniques often have increased access and proximity to open space and associated passive recreational opportunities. Efforts should be taken to preserve natural areas that maximize contiguous land and incorporate critical site features such as wetlands, floodplains and viewsheds where applicable.

Source: www.lakecountyohio.org

Design Criteria

Implementation of site fingerprinting strategies and other commonly associated LID practices are based on factors such as; land availability, allowable development density and site dimensions, natural topography, soil types, groundwater table characteristics, naturally sensitive site features, and general site layout. The boundaries of all areas that are to remain undisturbed should be clearly shown on construction drawings and identified onsite prior to construction activities. These areas should not be disturbed during construction, nor should they be used for material storage. Sites should be graded to promote the disconnection of impervious surfaces and to maximize opportunities for onsite infiltration.

Maintenance

The practice of site fingerprinting does not typically require routine maintenance activities. Any proposed open space areas should be maintained in an undisturbed vegetative state and formalized through establishment of a conservation easement or other formal documentation process, as applicable. Residential developments that incorporate site fingerprinting techniques are often part of a homeowners association that maintains and oversees common areas and assesses an ongoing fee.

Source: The Low Impact Development Center, Inc.

Plans & Specifications

Plans & specifications for site fingerprinting and any other associated LID practices shall be in accordance with this guidance document and local land development regulations. At a minimum, the following information should be submitted:

1. A site plan that identifies the proposed construction disturbance limits
2. Construction sequencing plan
3. Conservation easement or other formal documentation for conserved open space areas (as applicable)

SECTION 3

FILTRATION PRACTICES

BIORETENTION

Definition
Bioretention systems are vegetated stormwater treatment facilities that capture and temporarily store collected runoff and allow it to pass through an organic media filter bed. Landscaping is critical to the performance, function and aesthetics of bioretention systems and can include grasses, wildflowers, shrubs and/or trees that are tolerant to both wet and dry conditions. Bioretention facilities typically incorporate an underdrain mechanism to prevent prolonged ponding within the shallow surface depression.

Purpose
Bioretention facilities provide treatment to collected stormwater runoff by attenuating flows and filtering out suspended sediment and the attached pollutants (including metals, bacteria and nutrients) as the water passes through an organic filter matrix. Bioretention systems reduce the amount of suspended pollutants that drain from a site and can also reduce the amount of runoff from a site if designed to infiltrate. Infiltrating stormwater contributes to groundwater recharge and assists in causing a site to generate runoff volumes and flow rates more similar to pre-development conditions.

Conditions Where Practice Applies
Bioretention facilities are commonly used to treat stormwater from parking lots and residential developments. While bioretention facilities consume a relatively large amount of land area (approximately 5% of the contributing impervious area), they can often fit into existing parking lot islands or other landscaped areas. Bioretention facilities are normally effective in treating the runoff from drainage areas less than 5 acres in size and can be sited within areas of "hotspot" land uses (e.g. near fueling stations, chemical storage areas, etc.) as long as an impermeable liner is used at the bottom of the filter bed. Bioretention is often an appropriate stormwater treatment practice in retrofit locations and can commonly be accomplished by modifying existing landscaped areas.

Source: www.ia.nrcs.usda.gov

Design Criteria
Pretreatment of stormwater runoff prior to discharging into a bioretention facility is typically accomplished by a combination of vegetated surfaces and stone trenches which assist in settling out suspended sediment and spreading the incoming flow evenly. Stormwater should be conveyed to a bioretention facility in a non-erosive manner and are best applied at sites with relatively shallow slopes (usually about 5%). Bioretention facilities that are designed to utilize an underdrain system are not dependent upon site soils characteristics since stormwater runoff percolates through a prepared soil filter bed prior to discharge into

the underdrain network. Appropriate soil conditions are necessary if it is intended to have filtered runoff infiltrate into the underlying soils.

Bioretention treatment facilities should be designed with a soil bed that is a sand/ soil matrix covered by a mulch layer. It is important that the groundwater table not intersect the bottom of the bioretention filter bed, which could potentially cause groundwater contamination and/or treatment practice failure. Bioretention facilities are typically designed to pond six-inches of water within the shallow surface depression and include an overflow structure to convey flow from large storm events.

Source: South Burlington Stormwater Utility

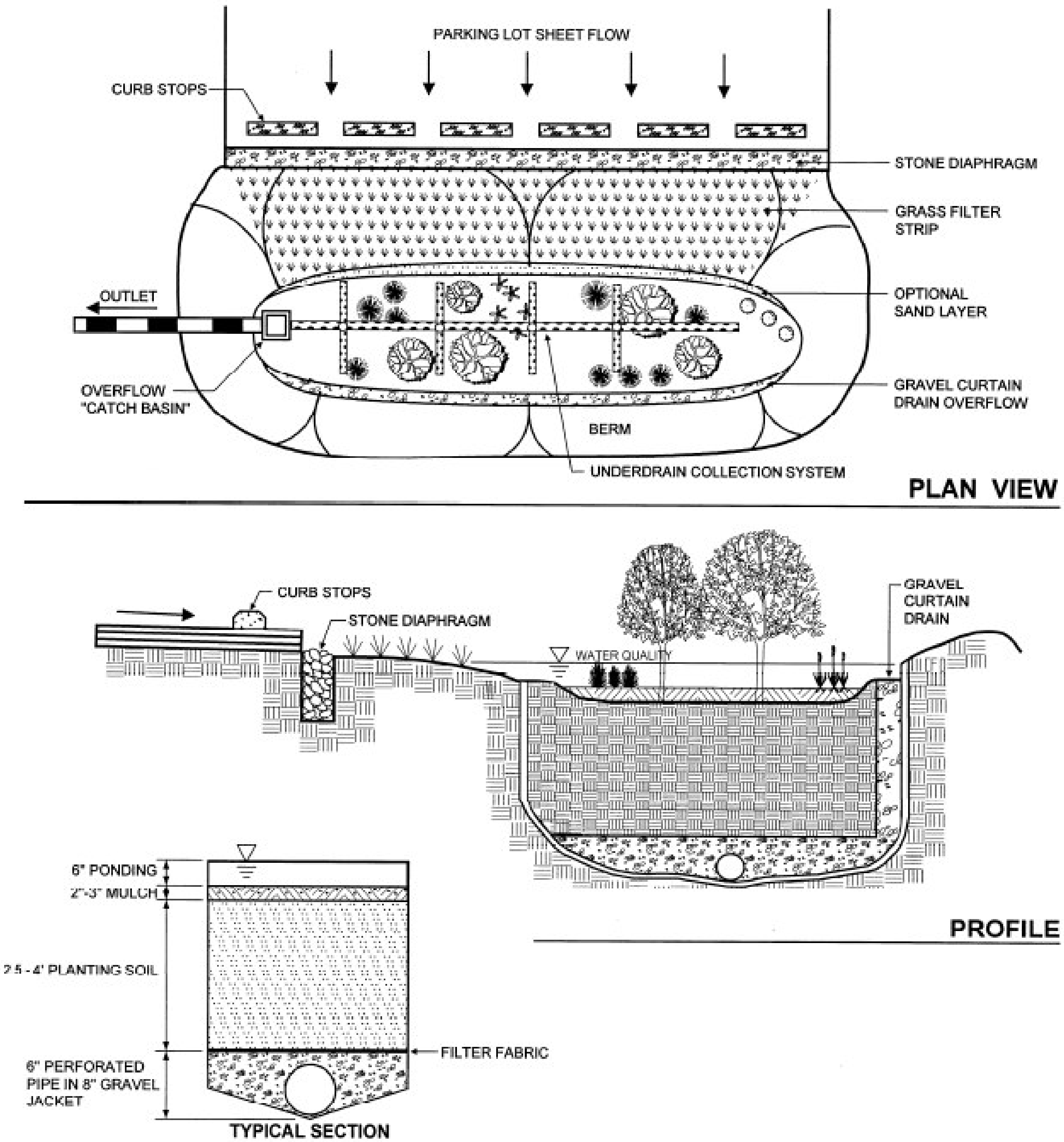
Bioretention systems provide water quality treatment and can also provide groundwater recharge treatment if they are designed without an underdrain mechanism. The Vermont Stormwater Management Manual (VSWMM) contains a comprehensive description of required elements, design guidance and a construction inspection checklist for bioretention facilities. **Figures 3-1** is an illustrations of a bioretention system, put forth within the VSWMM.

<u>Maintenance</u>
Bioretention areas require frequent maintenance initially to establish the selected plants. Eroded areas should be repaired and accumulated littler and debris be removed on an as needed basis. About once a year dead plants should be removed and replaced and the filter bed surface should be re-mulched. The VSWMM contains a detailed operation, maintenance and management inspection checklist for bioretention systems.

<u>Plans & Specifications</u>
Plans & specifications for constructing and installing bioretention treatment facilities shall be in accordance with this guidance document, local land development regulations and the Vermont Stormwater Management Manual. Submitted information should demonstrate that all design requirements of the treatment practice are met. At a minimum, the following information should be submitted:

1. Site information including but not limited to: contributing drainage area, land use, slope, and seasonal high groundwater elevation
2. Design calculations
3. Construction detail and sequencing plan
4. Maintenance plan

Figure 3-1 – Bioretention



Source: Vermont Stormwater Management Manual

VEGETATED BUFFER

Definition

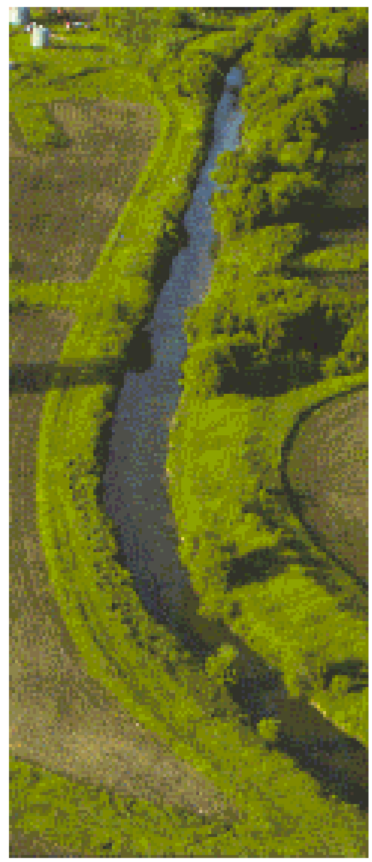
Vegetated buffers are undisturbed natural areas and planted areas where vegetation serves to manage stormwater runoff and provide a protective natural area along stream corridors. These vegetated areas can also provide aesthetic benefits, noise attenuation, functional floodplain and wildlife habitat. The term vegetated buffers is a general term that includes natural stream buffers and planted filter strips.

Purpose

Vegetated buffers provide stormwater treatment by dispersing and attenuating flows, filtering out suspended sediment and attached pollutants, and allowing for infiltration prior to stormwater runoff reaching an adjacent stream, river or wetland. These vegetated corridors reduce runoff volume, flow rate and pollutant loading being discharged into adjacent watercourses and can also reduce stream bank erosion and downstream flooding concerns. The primary function of a vegetated buffer is to protect and physically separate watercourses from disturbances resulting from land development.

Conditions Where Practice Applies

Vegetated buffers can be comprised of undisturbed native vegetation or planted natural areas. Buffer corridors are often preserved and incorporated into new development projects but can also be implemented at redevelopment sites if conditions allow. Although commonly used in retrofit applications adjacent to natural water courses, vegetated filter strips can be constructed as standalone stormwater treatment practices in low lying areas that are not located next to streams, rivers or wetlands. Vegetated buffers often provide passive recreational opportunities such as walking, although formal paths should not be constructed.



Source: www.nrcs.usda.gov

Design Criteria

Stormwater runoff flowing into vegetated buffer areas should be non-erosive sheet flow and may require the use of a level spreading device or large storm event bypass. The Vermont Stormwater Management Manual (VSWMM) provides a detailed description of stream buffers and associated schematics. In accordance with the VSWMM, contributing areas draining to a stream buffer area should be relatively flat (5% maximum slope) and have flow paths no greater than 150 feet for pervious surface and 75 feet for impervious surfaces. Furthermore, in accordance with the VSWMM stream buffers and vegetated filter strips should have a minimum width of 50 feet and 25 feet, respectively.

Disturbance to proposed stream buffer areas must be avoided during construction activities. Natural buffer area shall not be disturbed to accommodate the construction of a vegetated filter strip. The limits of all proposed buffer areas shall be clearly shown on all construction drawings and identified onsite prior to construction to prevent inadvertent disturbance. Permanently conserved buffer areas should be formalized through establishment of a conservation easement or other formal documentation process. **Figures 3-2** and **3-3** depict a stream buffer and vegetated filter strip respectively, as put forth in the VSWMM.

Maintenance

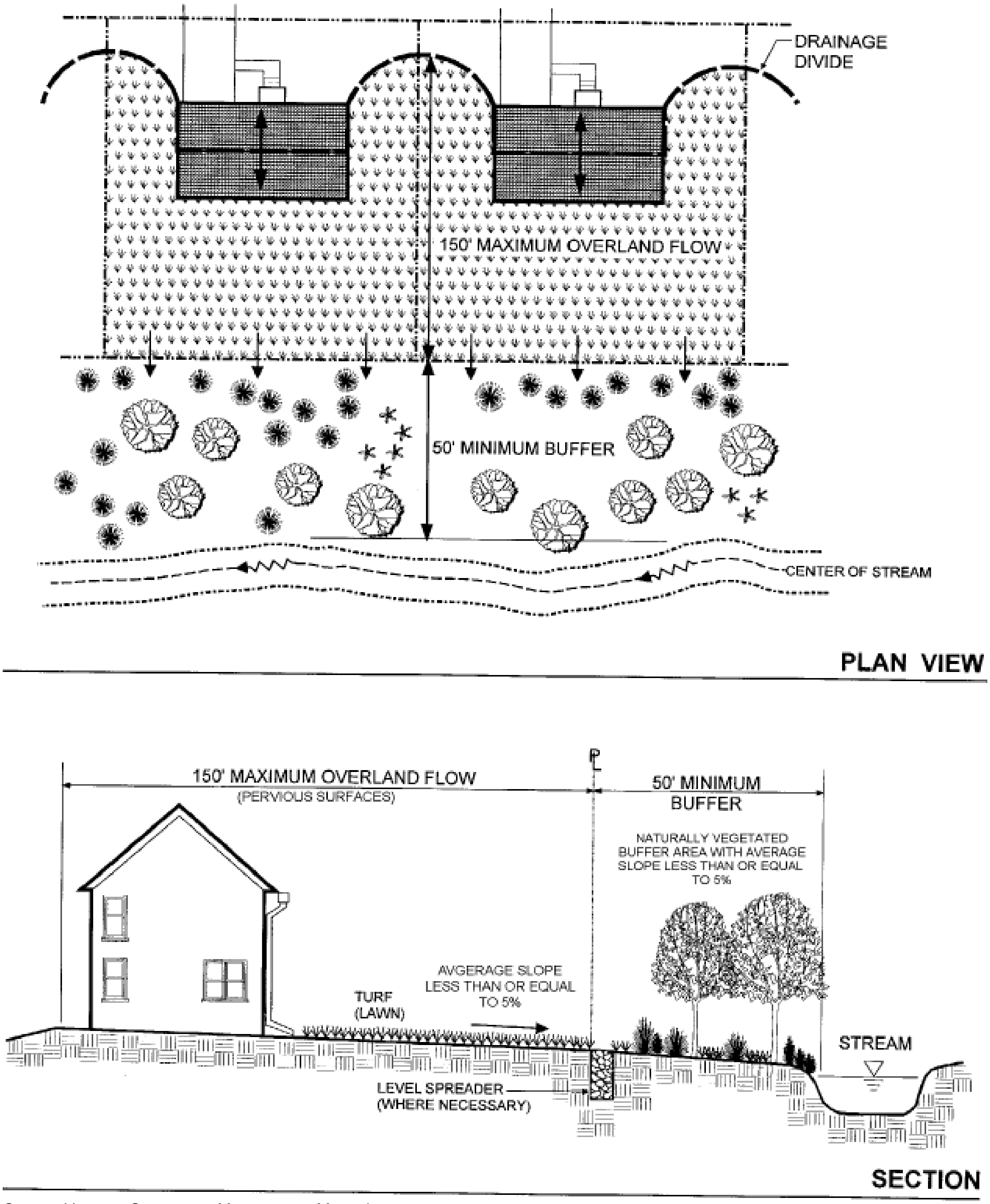
Eroded areas should be repaired and accumulated littler and debris be removed on an as needed basis. If applicable, grasses should be maintained to provide for a dense cover at a height of 4-6 inches. About once a year dead plants identified within planted buffer areas should be removed and replaced. If a level spreader is utilized, the system should be inspected frequently to ensure ongoing proper flow dispersion.

Plans & Specifications

Plans & specifications for vegetated buffers shall be in accordance with this guidance document, local land development regulations, and the Vermont Stormwater Management Manual. The applicant shall provide information demonstrating that all dimensional requirements for vegetated buffers are met. At a minimum, the following information should be submitted:

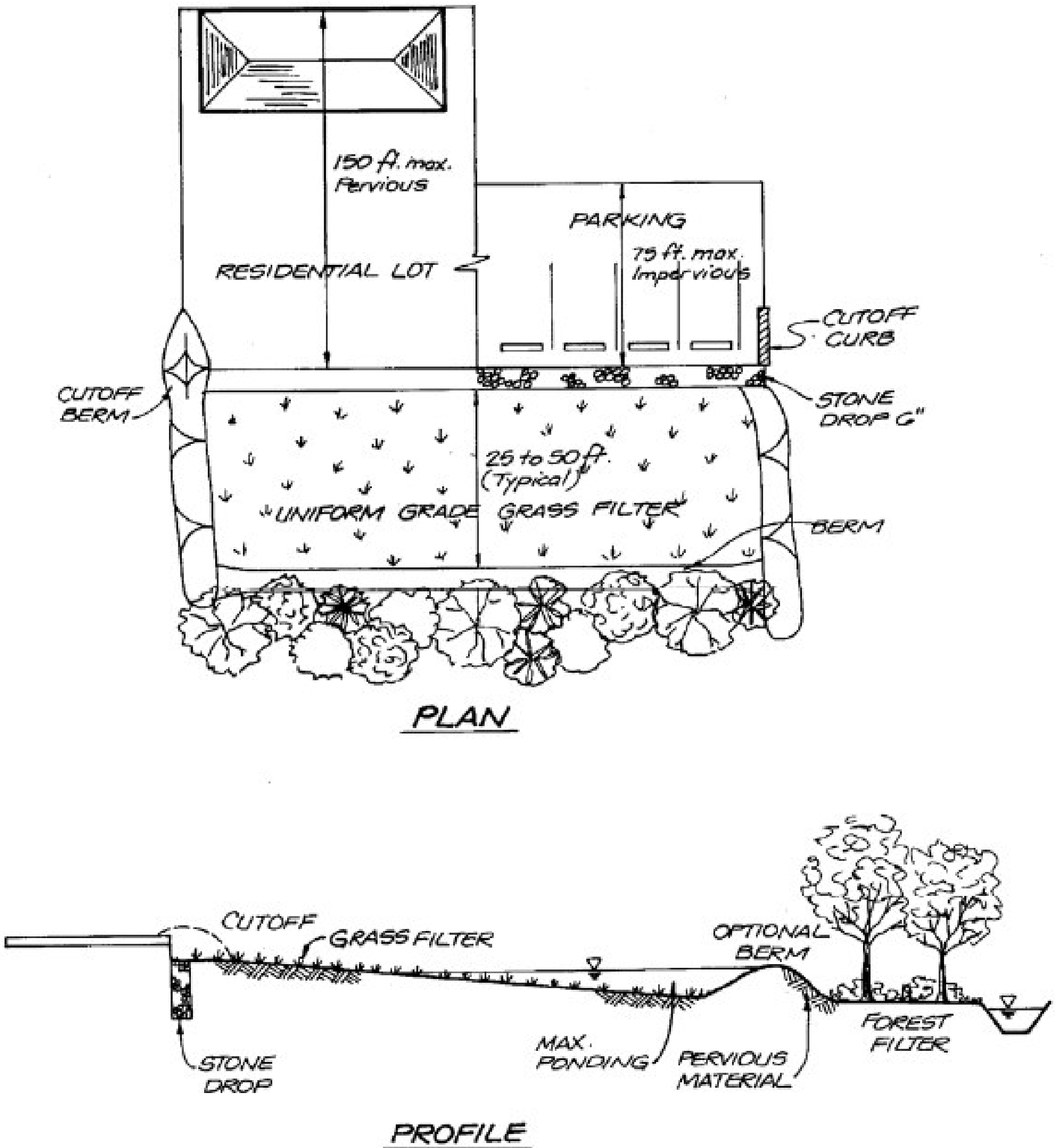
1. A site plan that identifies the contributing drainage area (including contributing flow path lengths and average overland slope) and vegetated buffer boundaries
2. Planting schedule (as applicable)
3. Construction details (as applicable)
4. Conservation easement or other formal documentation (as applicable)

Figure 3-2 – Stream Buffer



Source: Vermont Stormwater Management Manual

Figure 3-3 – Vegetated Filter Strip



Source: Vermont Stormwater Management Manual

SECTION 4

INFILTRATION PRACTICES

DISCONNECTION OF IMPERVIOUS AREA

Definition

Impervious surfaces are considered "connected" when stormwater runoff from these areas is conveyed directly to receiving waters by hydraulically efficient drainage systems, such as enclosed storm drains and stormwater piping. The practice of "disconnecting" impervious areas diverts runoff to vegetated pervious surfaces thereby promoting onsite filtration and infiltration into the underlying soil.

Purpose

Disconnection of impervious area is a low impact development (LID) strategy that assists in maintaining pre-development hydrologic and water quality characteristics by providing groundwater recharge. Suspended sediment and the attached pollutants in stormwater runoff are filtered out as stormwater flows over and through vegetated porous surfaces. The disconnection of impervious areas also prevents downstream flood hazards and reduces the need to construct new stormwater infrastructure.

Conditions Where Practice Applies

The disconnection of impervious surfaces is applicable to a variety of land uses such as; residential, commercial, industrial and institutional. The implementation of this LID practice requires vegetated pervious surfaces be located adjacent to the impervious area to be disconnected and is not appropriate in "hotspot" areas that can generate excessive stormwater pollutants (e.g. near fueling station, chemical storage areas, etc.). Benefits of this strategy include; the incorporation of pervious lawns, meadows, and/or forested areas into site designs and reduced construction and maintenance costs associated with stormwater infrastructure.

Source: Environmental Services, Portland OR

Design Criteria

For the purpose of impervious area disconnection, vegetated pervious areas receiving stormwater runoff should be relatively flat (5% maximum slope) and have underlying permeable soils. Spreading devices and/or temporary storage devices may be needed in areas of poor soil permeability. The Vermont Stormwater Management Manual (VSWMM) provides a detailed description of impervious area disconnection methods for both rooftop and non-rooftop areas. In accordance with the VSWMM, a pervious area flow path length must be equal to or greater than the contributing impervious area flow path length (75 feet maximum). Furthermore, impervious surface area draining to any one-discharge location should not exceed 1,000 square feet. Issues of potential basement seepage and "re-connection" need to be considered when implementing gutter/downspout rooftop disconnections. The VSWMM also provides an example of a properly disconnected rooftop (see **Figure 4-1**).

Maintenance

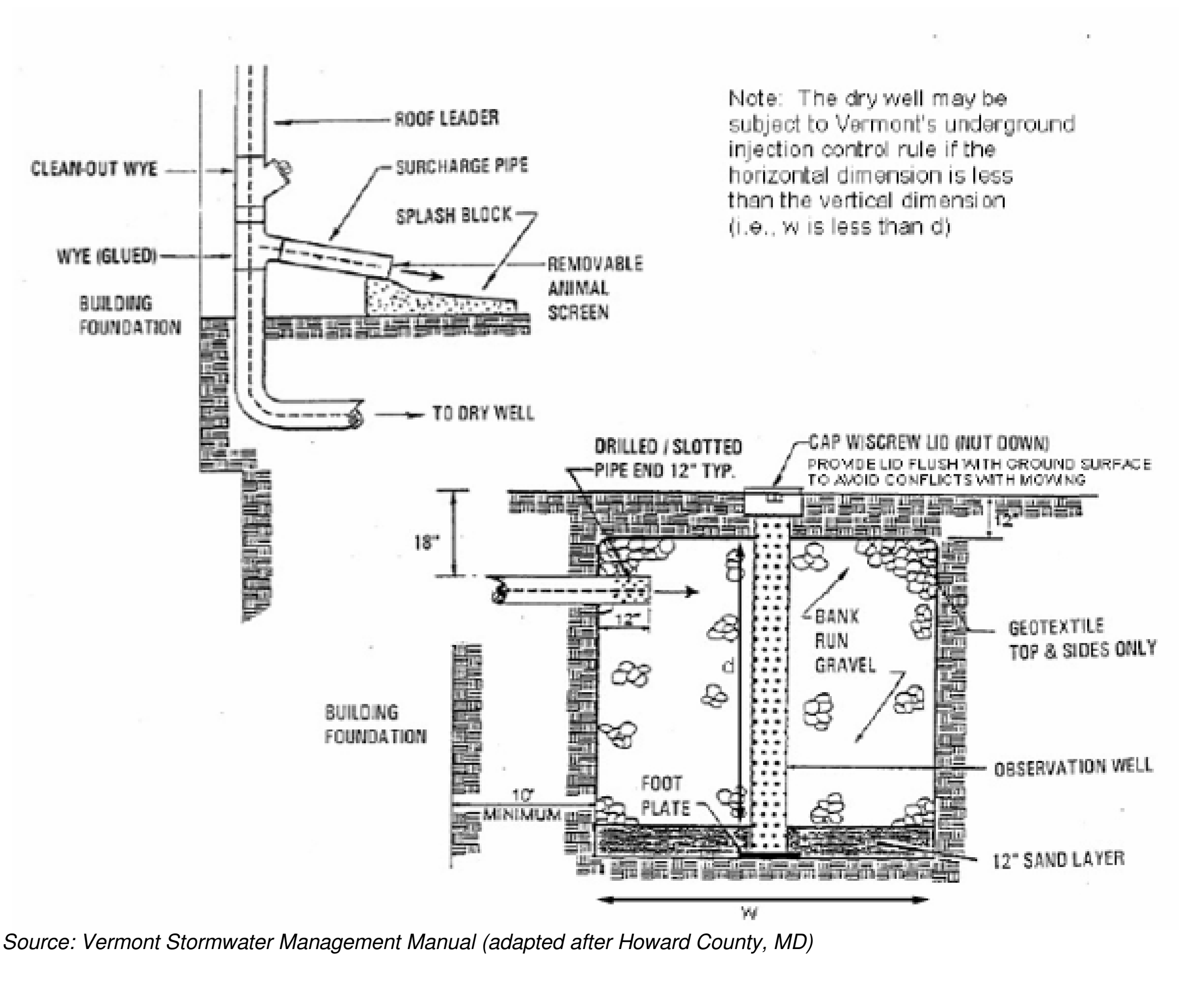
There are no formal maintenance requirements associated with the practice of impervious area disconnection. Vegetated pervious areas should be periodically inspected and maintained as needed to prevent erosion and the accumulation of sediment and debris.

Plans & Specifications

Plans & specifications for the disconnection of impervious area shall be in accordance with this guidance document and the Vermont Stormwater Management Manual. The applicant shall provide information demonstrating that all dimensional requirements for disconnection are met. At a minimum, the following information should be submitted:

1. A site plan that identifies the disconnected impervious area (including flow path length and contributing drainage area size) and the pervious area that will receive the stormwater runoff (including flow path length, slope and soil information)
2. Construction details (as applicable)

Figure 4-1 – Dry Well & Downspout Schematic



Source: Vermont Stormwater Management Manual (adapted after Howard County, MD)

INFILTRATION BASIN

Definition

Infiltration basins are shallow impoundments that treat stormwater runoff through the process of infiltration. Stormwater is temporarily stored within the impoundment prior to passively infiltrating through the bottom of the basin and into the underlying soil typically over a two-day period.

Purpose

Suspended sediment and the attached pollutants in stormwater runoff are filtered out as water infiltrates into the underlying soil media. Infiltration basins reduce the amount of stormwater runoff and suspended pollutants that drain from a site. Infiltrating stormwater recharges groundwater and reduces runoff. When runoff is infiltrated to groundwater, the rate and volume of water leaving the site becomes similar to pre-development conditions.

Conditions Where Practice Applies

Infiltration basins require a significant amount of land and are well suited for residential and commercial development land uses. All infiltration practices are limited to sites that have appropriate soil types and groundwater table characteristics. Infiltration basins are typically most effective for drainage areas of less than 5 acres, although larger areas can be accommodated (10 acre maximum) if site soil conditions are highly permeable. It is important that sediment laden stormwater not be directed to infiltration facilities to prevent premature clogging.

Source: www.wsud.org

Design Criteria

To be suitable for infiltration, underlying soils need to have an infiltration rate of at least 0.5 inch/hr and a 3-foot separation between the bottom of infiltration structure and the seasonally high groundwater table. Infiltration basins cannot be sited where the natural slope of the land is greater than 15%, within areas of "hotspot" land uses (e.g. near fueling stations, chemical storage areas, etc.), and within 100 feet of any water supply well. Infiltration basins are typically designed with both a principal outlet structure and emergency spillway to allow for the passage of large storm events (see **Figure 4-2**). An underdrain system is also commonly incorporated into the design to prevent future ponding within the basin. The Vermont Stormwater Management Manual contains a comprehensive description of required elements, design guidance and a construction inspection checklist for infiltration basins.

Maintenance

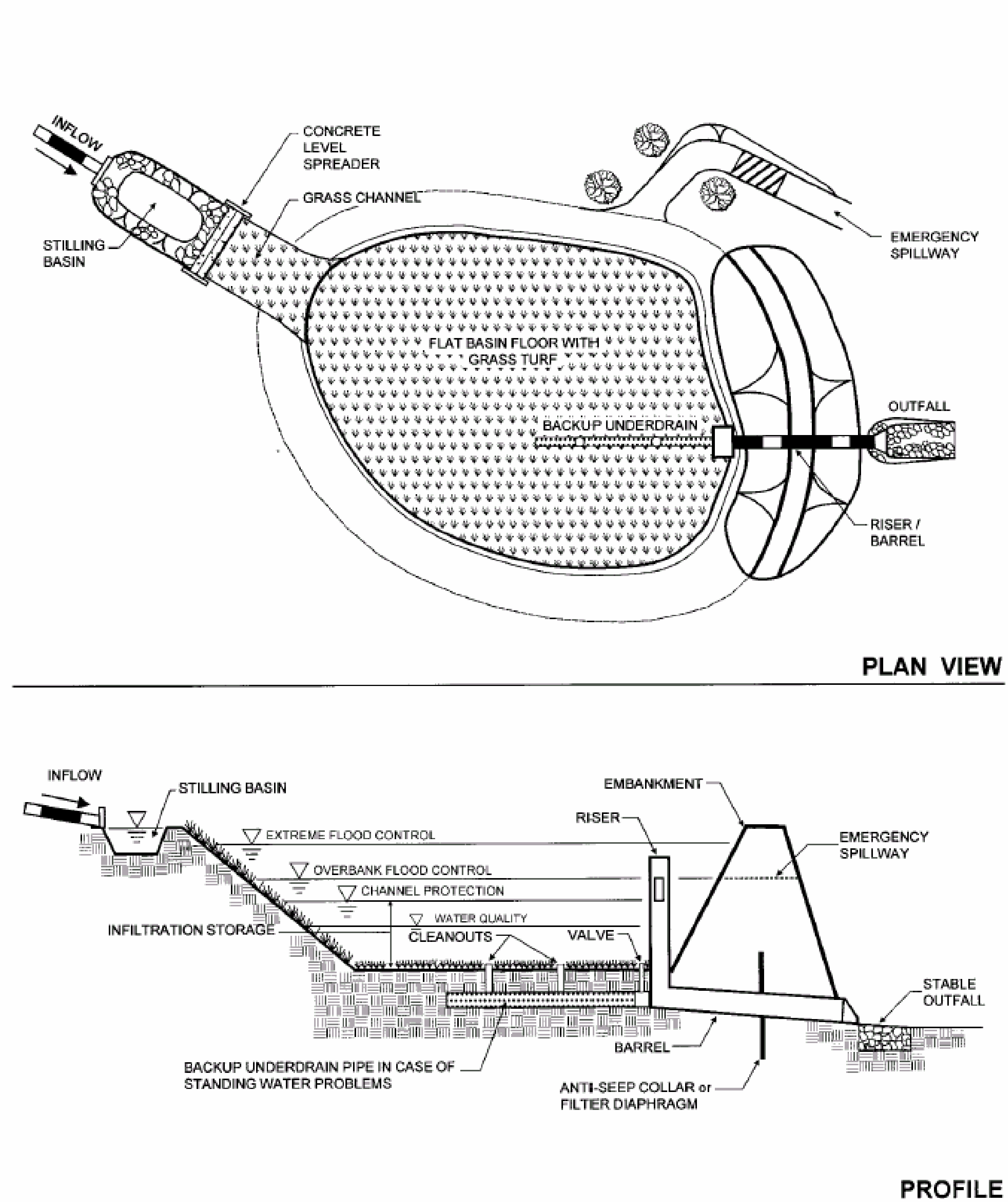
Recommended maintenance activities include system inspection following significant storm events or at least on a semi-annual basis to ensure proper system function, periodic removal of sediment and debris, and mowing as needed.

Plans & Specifications

Plans & specifications for constructing and installing an infiltration basin shall be in accordance with this guidance document, local land development regulations, and the Vermont Stormwater Management Manual. Submitted information should demonstrate that all design requirements of the treatment practice are met. At a minimum, the following information should be submitted:

1. Site information including but not limited to: contributing drainage area, land use, slope, soil type, infiltration rate and seasonal high groundwater elevation
2. Design calculations
3. Construction detail and sequencing plan
4. Maintenance plan

Figure 4-2 - Infiltration Basin



Source: Vermont Stormwater Management Manual

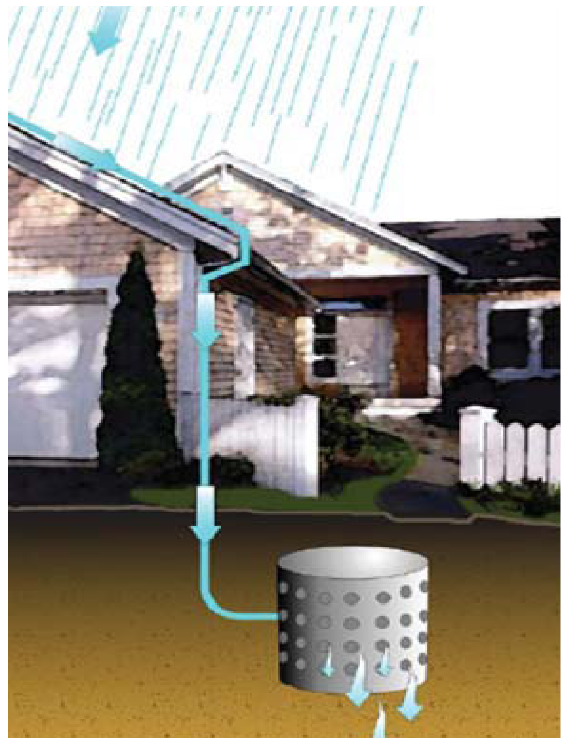
INFILTRATION TRENCH

Definition

Infiltration trenches are underground chambers filled with crushed stone that treat stormwater runoff through the process of infiltration. Stormwater is temporarily stored within the voids of the stones, and is allowed to infiltrate through the bottom of the chamber and into the underlying soil media typically over a several day period. Infiltration trenches are also commonly referred to as dry wells.

Purpose

Suspended sediment and the attached pollutants in stormwater runoff are filtered out as water infiltrates into the underlying soil media. Infiltration trenches reduce the amount of stormwater runoff and suspended pollutants that drain from a site. Infiltrating stormwater recharges groundwater and reduces runoff. When runoff is infiltrated to groundwater, the rate and volume of water leaving the site becomes similar to pre-development conditions.



Source: LID Guidance Manual for Maine Communities, Maine State Planning Office, 2006

Conditions Where Practice Applies

Infiltration trenches have a relatively small footprint and can be sited in locations such as: residential lots, medians, parking lot islands and along the edges of streets. All infiltration practices are limited to sites that have appropriate soil types and groundwater table characteristics. Infiltration trenches are typically effective for drainage areas of less than 5 acres and are not appropriate in "hotspot" areas that can generate excessive stormwater pollutants (e.g. near fueling stations, chemical storage areas, etc.). Infiltration trenches are often a viable choice for treating rooftop runoff from residential development (see **Figure 4-1**) but can also be appropriate for larger areas such as parking lots if pretreatment is provided (see **Figure 4-3**). It is important that sediment laden stormwater not be directed to infiltration facilities to prevent premature clogging.

Design Criteria

To be suitable for infiltration, underlying soils need to have an infiltration rate of at least 0.5 inch/hr and a 3-foot separation between the bottom of infiltration structure and the seasonally high groundwater table. Infiltration trenches cannot be sited where the natural slope of the land is greater than 15%, within areas of "hotspot" land uses, and within 100 feet of any water supply well. Infiltration trenches are typically designed with an overflow to allow for the passage of large storm events and are commonly constructed with an observation well. The Vermont Stormwater Management Manual (VSWMM) contains a comprehensive description of required elements, design guidance and a construction inspection checklist for infiltration trenches.

Maintenance

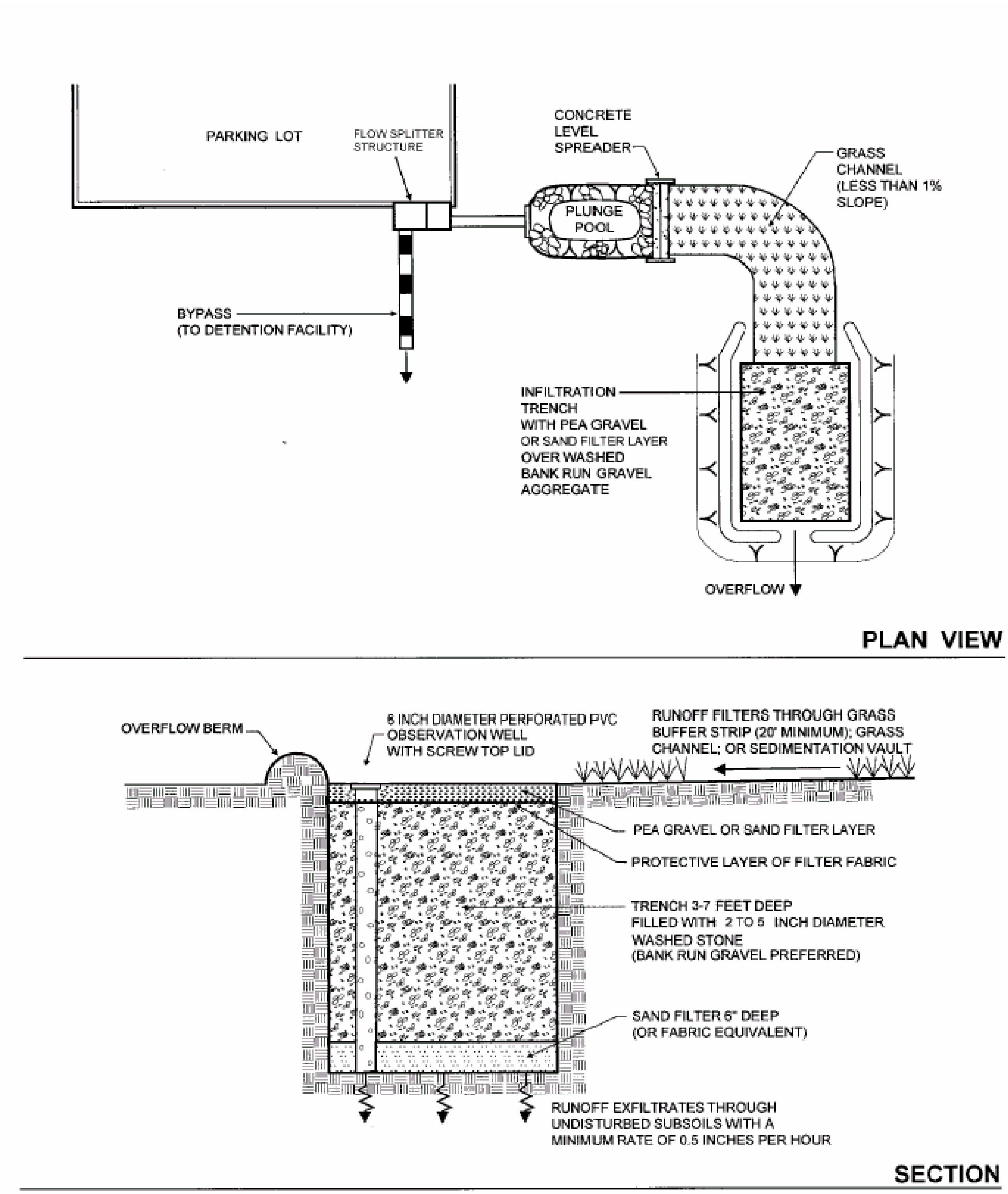
Recommended maintenance activities include system inspection following significant storm events or at least on a semi-annual basis to ensure proper system function, periodic removal of sediment and debris and, if possible, allowing trenches to sit dry for an extended period of time. The VSWMM contains an operation, maintenance and management inspection checklist for infiltration trenches.

Plans & Specifications

Plans & specifications for constructing and installing an infiltration trench shall be in accordance with this guidance document, local land development regulations, and the Vermont Stormwater Management Manual. Submitted information should demonstrate that all design requirements of the treatment practice are met. At a minimum, the following information should be submitted:

1. Site information including but not limited to: contributing drainage area, land use, slope, soil type, infiltration rate and seasonal high groundwater elevation
2. Design calculations
3. Construction detail and sequencing plan
4. Maintenance plan

Figure 4-3 - Infiltration Trench



Source: Vermont Stormwater Management Manual

POROUS PAVEMENT

Definition

Porous pavement is a permeable pavement surface with an underlying stone layer that functions as a temporary reservoir storing stormwater runoff before allowing it to infiltrate into the subsoil. Porous pavement is used as a replacement for traditional pavement materials and allows stormwater from paved areas to infiltrate directly into the underlying soil media. The term porous pavement is a general term that includes the following materials: porous asphalt, porous concrete and porous pavers.

Porous asphalt and porous concrete have the same visual appearance as traditional asphalt and concrete, respectively, but are manufactured without the standard amount of fine material that is used in the manufacturing of traditional materials. The absence of fine material creates void spaces within the asphalt and concrete that allow for the infiltration of stormwater. Porous pavers include concrete interlocking blocks and synthetic grid systems with void spaces designed to allow grass to grow or to be filled with gravel.

Porous pavement is shown in the foreground of the image above
Source: South Burlington Stormwater Utility

Purpose

Porous pavement provides a functional and durable surface while reducing the amount of stormwater runoff and suspended pollutants that drain from a site. Infiltrating stormwater recharges groundwater and reduces runoff. When runoff is infiltrated to groundwater, the rate and volume of water leaving the site becomes similar to pre-development conditions. Additional reported benefits of porous pavement include a reduction in; road noise, travel spray, required winter maintenance and development of black ice.

Conditions Where Practice Applies

Porous pavement practices can be well suited for roadway, driveway, parking, sidewalk and courtyard applications as a replacement for traditional pavement materials at both new and redevelopment sites. Since porous pavements allow for the infiltration of stormwater into the underlying soil media, consideration should be given to site soil types and groundwater table characteristics when siting a proposed application of these permeable materials. It is important that porous paved surface remain free of sand and fine sediment in order to prevent premature clogging.

Although porous pavement typically costs more than traditional pavement, substantial cost savings can be realized due to the reduced need for stormwater management infrastructure including catch basins, drainage pipe and structural treatment facilities.

Design Criteria

To be suitable for infiltration, underlying soils need to have an infiltration rate of at least 0.5 inch/hr and a 3-foot separation between the bottom of the stone reservoir and the seasonally high groundwater table. The stone layer located beneath the porous pavement surface should be constructed with clean aggregate on a relative flat slope (5% maximum) to allow for uniform infiltration. In cold climates, designs should include stone reservoirs of at least 24-inches deep to reduce the risk of frost heaves. Porous pavement should not be sited within areas of “hotspot” land uses (e.g. near fueling stations, chemical storage areas, etc.), within 100 feet of any water supply well and in areas with ongoing earth disturbance. Underdrain systems are often incorporated into the design of porous pavement facilities in areas of unsuitable site soil or groundwater conditions and to prevent surface ponding.

Source: www.dakotacountyswcd.org

Although porous pavement can provide infiltration and subsequent groundwater recharge it is not formally recognized as an acceptable stormwater treatment practice within the Vermont Stormwater Management Manual (VSWMM). There are many informative internet resources regarding porous pavement including but not limited to: www.unh.edu/erg/cstev/, www.stormatercenter.net, and www.perviouspavement.org which contain extensive information and links to additional resources.

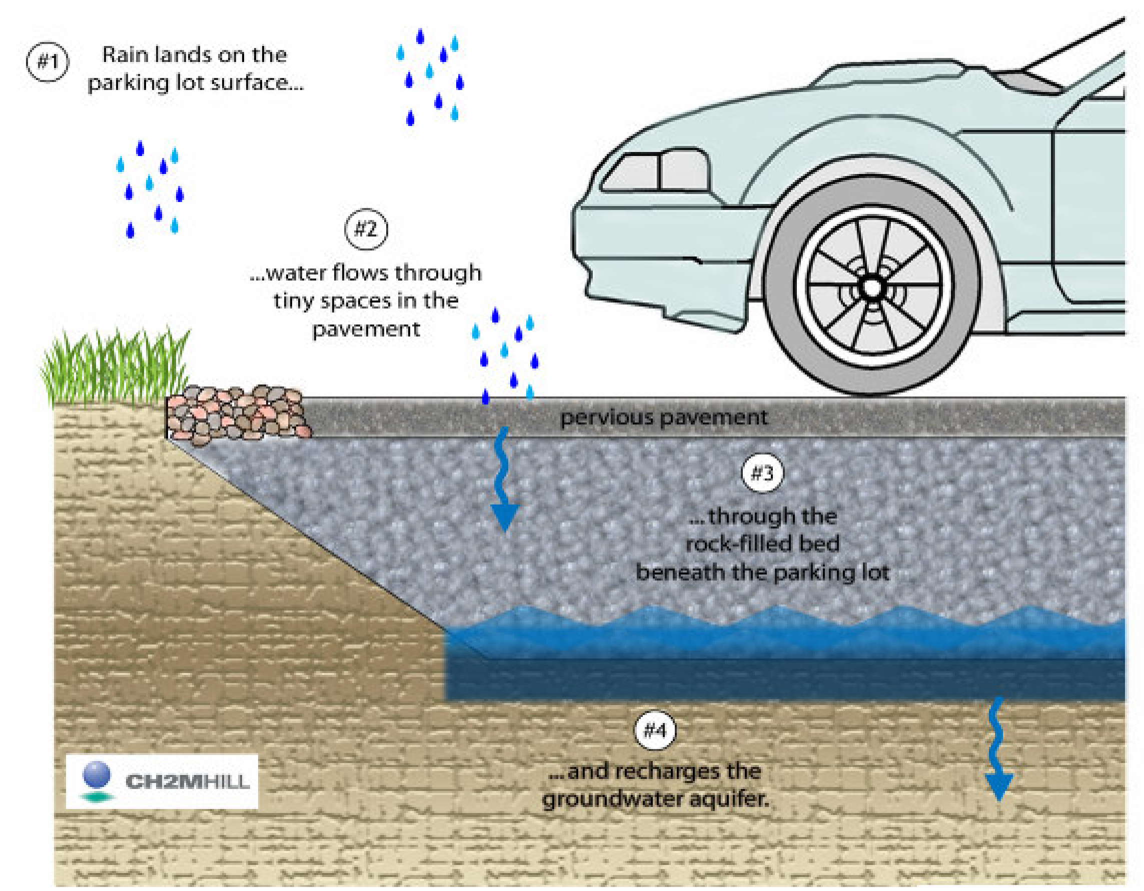
Maintenance

Recommended maintenance activities include: monthly inspections to ensure that areas are clean, that surface ponding is not occurring, and that upstream and adjacent areas are sufficiently stabilized. Porous asphalt and concrete should be vacuum swept at least twice per year in order to remove accumulated sediment and retain adequate surface permeability. Efforts must be made to ensure that runoff from construction activities is directed away from porous paved surfaces and that sand is not used for winter maintenance on such surfaces.

Plans & Specifications

Plans & specifications for porous pavement shall be in accordance with this guidance document, local land development regulations, and other reputable sources such as the internet resources identified herein. Submitted information should demonstrate that all design requirements of the treatment practice are met. At a minimum, the following information should be submitted:

1. Site information including but not limited to: contributing drainage area, land use, slope, soil type, infiltration rate and seasonal high groundwater elevation
2. Design calculations
3. Construction detail and sequencing plan
4. Material specification cut sheet
5. Maintenance plan



Source: CH2M HILL

RAIN GARDENS

Definition
Rain gardens are vegetated stormwater treatment facilities that capture and temporarily store collected runoff and allow it to filter through a soil media bed. Rain gardens are shallow depressions that contain aesthetically pleasing, water tolerant plantings and can be designed to include an underdrain mechanism.

Purpose
Rain gardens provide stormwater treatment by attenuating flows and filtering out suspended sediment and the attached pollutants (including metals, bacteria and nutrients) as the water passes through an organic filter matrix. Filtered groundwater percolates into the underlying soils and replenishes the groundwater table. Reduced runoff from the site assists in preventing downstream flooding and erosion. Rain gardens can also provide aesthetic benefits and wildlife habitat.

Conditions Where Practice Applies
Rain gardens are commonly sited to treat stormwater runoff from residential lots and parking areas. Rain gardens are best suited for relatively flat, low areas that have well drained soils. Consideration should be given to ensure that gardens are sited away from buildings to prevent damage due to wetness or flooding (10-feet recommended) and not over septic tanks or leach fields. It is also preferred to site rain gardens in full or partially sunny locations to facilitate the drying process and plant growth. Rain gardens are often an appropriate stormwater treatment practice to mitigate rooftop runoff and are commonly used in retrofit locations where they can be implemented by modifying existing landscaped areas.

Source: Winooski Natural Resources Conservation District

Design Criteria
Rain gardens are sized based on the size of the impervious area draining to them, the site soil and slope. Based on these factors gardens can range in size from approximately 10% to 40% of the contributing impervious surface area. Rain gardens are typically designed to pond no more than six-inches of water within the shallow surface depression and must allow for the safe passage of runoff from large storm events. Rain gardens should have a level bed and be constructed in areas where soil conditions will allow for the infiltration of collected stormwater. It is important that runoff be conveyed to a rain garden in a non-erosive manner and should not be sediment laden.

At least two inches of compost should be added to a rain garden and mixed into the native soil to assist in moisture retention and to sustain plant growth. Plants must be able to tolerate extreme moisture conditions but should not require consistent wet soils or standing water. The Vermont Rain Garden Manual contains a list of appropriate plants for rain gardens. A layer or organic mulch spread over the surface of a rain garden provides for the decomposition of organic material, retains moisture, and is also critical in pollutant removal.

Although rain gardens are designed to provide both water quality and ground water recharge treatment, they are not formally recognized as an acceptable stormwater treatment practice within the Vermont Stormwater Management Manual (VSWMM) at this time. Rain gardens are similar in concept to bioretention facilities and much of the design guidance provided for bioretention facilities within the VSWMM is applicable to rain gardens. The Vermont Rain Garden Manual (http://vacd.org/winooski/VtRainGardenManual.pdf) is a user-friendly guidance document that describes the steps involved with rain garden siting, sizing, design, installation, and maintenance. **Figure 4-4** is an illustration of a typical rain garden configuration.

Source: www.co.monroe.in.us

Maintenance

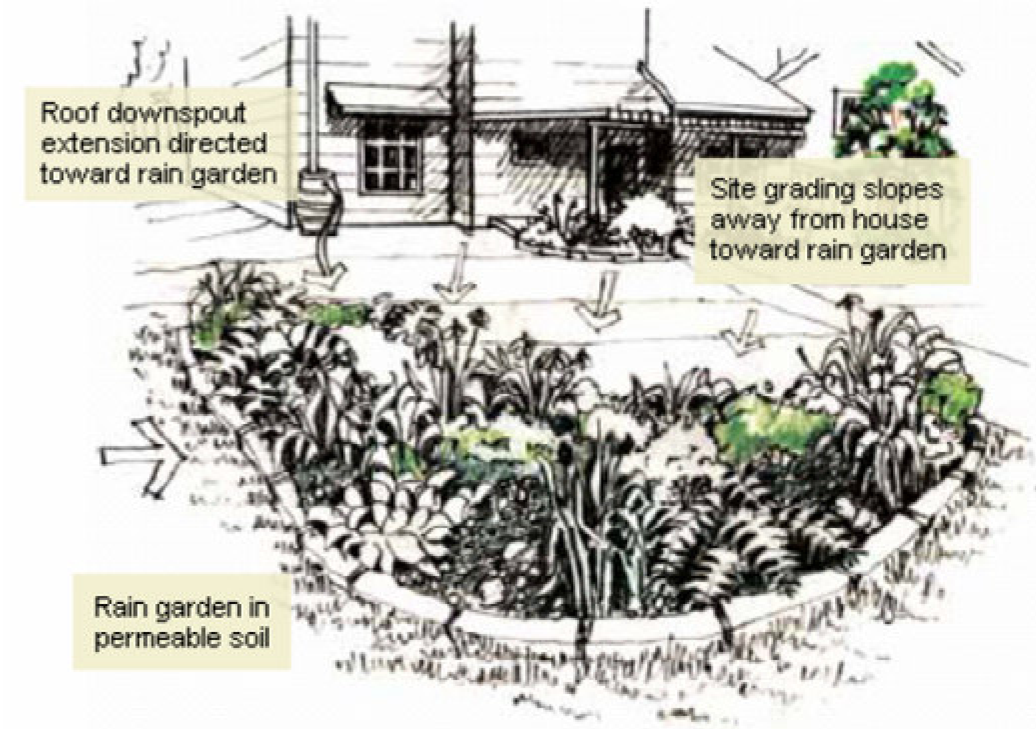
Rain gardens require frequent watering initially to establish the selected plants. Eroded areas should be repaired and accumulated littler and debris removed as needed. About once a year dead plants and weeds should be removed and the filter bed surface should be re-mulched.

Plans & Specifications

Plans & specifications for constructing and installing rain gardens shall be in accordance with this guidance document, local land development regulations, and the Vermont Rain Garden Manual. Submitted information should demonstrate that all design requirements of the treatment practice are met. At a minimum, the following information should be submitted:

1. Site information including but not limited to: contributing drainage area, land use, slope, and native soil type
2. Sizing calculations
3. Construction detail and sequencing plan
4. Planting plan
5. Maintenance plan

Figure 4-4 – Rain Garden Layout



Source: LID Guidance Manual for Maine Communities, Maine State Planning Office, 2006

SECTION 5

LANDSCAPING PRACTICES

LANDSCAPING PRACTICES

Definition

There are a variety of low impact development (LID) landscaping practices that can be utilized to minimize the stormwater quality and quantity impacts commonly caused by land development projects. In general, these landscaping strategies attempt to mimic pre-development site conditions by enhancing opportunities for onsite infiltration, filtration and/or evapotranspiration of stormwater runoff. Examples of such LID landscaping practices include:

- Planting native, drought tolerant plants
- Converting turf areas to shrubs & trees
- Reforestation
- Planting wildflower meadows rather than turf in open space

In addition, LID landscaping strategies often attenuate noise, provide an increased sense of privacy and require less irrigation then traditional landscaping practices.

Purpose

By imitating pre-development site vegetation, LID landscaping techniques allow for precipitation to be effectively infiltrated into the underlying groundwater table or taken up by plants and ultimately conveyed into the atmosphere. These practices reduce the total runoff volume and flow rates that discharge from a site, thereby reducing the demands placed on downstream stormwater infrastructure and the potential for erosion and surface flooding.

Conditions Where Practice Applies

LID landscaping practices are appropriate for a wide variety of new and redevelopment projects including residential, commercial and transportation land uses. Landscaping techniques, such as planting wildflower meadows and drought tolerant plants, are relatively inexpensive to implement and require minimal site disturbance and ongoing maintenance.

Source: www.riversides.org

Design Criteria

Opportunities for applying LID landscaping strategies are based on site specific factors such as; available land, soil type, amount of sunlight, natural topography, and regional climatic conditions. It is critical that selected vegetation be native or adapted plant varieties able to withstand site and climate conditions. If LID landscaping strategies are going to be used adjacent to roadways, consideration should be given to maintaining sufficient visual site distances. Adequate erosion prevention and sediment control measures shall be used in areas where existing turf is disturbed in the process of implementing LID landscaping practices. Appropriate precautions should always be taken prior to earth disturbance activities to avoid potentially disturbing existing underground utilities.

Maintenance

In general, maintenance requirements for LID landscaping practices are less than those associated with conventional landscaping practices. LID landscaped areas may initially require the application of fertilizer and frequent watering to establish selected plants. However, once established these areas should require little to no ongoing watering and fertilizing. Periodic maintenance activities commonly include; replanting damaged vegetation, trimming and pruning established shrubs and trees and removing weeds and debris.

Plans & Specifications

Plans & specifications for LID landscaping practices shall be in accordance with this guidance document, local land development regulations and other reputable sources such as the Prince George's County, MD Bioretention Manual. At a minimum, the following information should be submitted:

1. A site plan that identifies the proposed LID landscaping practice, site slope and soil type
2. Planting schedule

SOIL CONSERVATION & AMENDMENTS

Definition

Conserving and amending site soils are low impact development (LID) strategies that minimize stormwater related impacts commonly caused by construction activities. These practices include protecting native site soils for use in final site landscaping and amending impacted soils to restore pre-development characteristics that allow for the storage and infiltration of stormwater.

Purpose

Conventional land development activities can significantly disturb native site soils and commonly include the removal of the upper, organically rich materials and compaction of the exposed sub-soils. These actions alter a sites hydrology and reduce the ability for precipitation to infiltrate into the underlying soils and groundwater table. As a result landscaped areas established within impacted soil can generate stormwater runoff at a rate significantly greater than pre-development conditions. Soil conservation and amendment techniques that maintain or restore organic soil content can be used to assist in maintaining pre-development hydrologic and water quality characteristics by improving onsite flow attenuation and infiltration. The implementation of these practices reduce the total runoff volume and flow rates that discharge from a site thereby reducing the demands placed on downstream stormwater infrastructure and the potential for erosion and surface flooding.

Source: South Burlington Stormwater Utility

Conditions Where Practice Applies

Soil conservation and amendment practices are appropriate for a wide variety of new and redevelopment projects including residential, commercial, industrial and transportation land uses. These techniques reduce ongoing fertilization and irrigation needs and are appropriate on both flat and sloped surfaces.

Design Criteria

Site soil conservations efforts should start with limiting disturbance activities through practices such as site fingerprinting. In areas that are to be disturbed, existing topsoil should be removed, stockpiled and covered for later use. It is recommended within the Western Washington Stormwater Manual (2003) that the organic content of soil to be used in planting beds and to establish turf should be a minimum of 10% and 5% on a dry weight basis, respectively. Organically rich material, such as compost, can be tilled into impacted topsoil to achieve the desired organic content. In general, the non-compacted topsoil layer should be 8 inches to 12 inches deep and have a pH appropriate for the selected vegetation. Following tilling, the topsoil layer should be raked level, planted and mulched immediately. Caution should be used when incorporating soil amendments in the vicinity of existing trees and shrubs to avoid root damage. The boundaries of all areas that are to remain undisturbed should be clearly shown on construction drawings and identified onsite prior to construction activities.

Maintenance

Soil conservation and amendment practices often result in improved plant growth. Periodic maintenance activities commonly include; replanting damaged vegetation, trimming and pruning established shrubs and trees and removing weeds and debris. Landscaped areas established in organically sufficient topsoil do not typically require fertilization and often need less irrigation than those areas established in impacted soil. Efforts should be taken to reduce excessive soil compaction in conserved and amended areas.

Plans & Specifications

Plans & specifications for soil conservation and amendment practices shall be in accordance with this guidance document and other reputable sources such as the LID Technical Guidance Manual for Puget Sound. At a minimum, the following information should be submitted:

1. A site plan that identifies the location of the proposed soil conservation and amendment practice and disturbance limits (as applicable)
2. Proposed soil amendment specifications (as applicable)
3. Construction sequencing plan
4. Planting schedule

SECTION 6

RUNOFF CONVEYANCE PRACTICES

RUNOFF CONVEYANCE PRACTICES

Definition

There are a variety of low impact development (LID) runoff conveyance practices that can be utilized to minimize land development impacts on surface water quality and assist in maintaining pre-development hydrologic characteristics. Examples of such LID runoff conveyance practices include:

- Roughening Surfaces
- Creating Long Flow Paths over Landscaped Areas
- Creating Terraces & Check Dams

These site design strategies increase the time it takes for stormwater runoff to concentrate and flow off of a site thereby increasing the potential for onsite infiltration and reducing stormwater discharge flow rates.

Purpose

Runoff conveyance practices that reduce the onsite velocity of stormwater runoff increase the opportunity for groundwater recharge and the associated reduction in runoff volume. As the time it takes runoff to flow across a site increases, the peak discharge rates generated from that site decreases. Reduced flow velocities and discharge rates can reduce the demands placed on downstream stormwater conveyance infrastructure and the potential for erosion and surface flooding.

Conditions Where Practice Applies

LID runoff conveyance practices are appropriate for a wide variety of land development projects including residential, commercial and transportation land uses and can be utilized for both construction and post-construction phases. Such techniques are often suitable on sloped areas that are the result of earth grading activities.

Design Criteria

Consideration should be given to ensure that the use of LID runoff conveyance techniques that increase a site's "time of concentration" do not cause problems associated with surface flooding or standing water. Such techniques should only be used where site safety and drainage can adequately be maintained. Surface roughness methods are often used for construction and post-construction phases and consist of site grading, establishment of vegetation and the use of coarse stone and aggregate. **Figure 6-1** depicts surface roughening techniques applied during construction activities. If site flow paths are going to extend through landscaped areas that the selected vegetation be tolerant to wet conditions. **Figure 6-2** illustrates the use of earthen check dams and terraces on a previously sloped site. It is critical that steep terrace slopes be effectively stabilized to prevent ongoing erosion concerns.

Figure 6-1 – Construction Phase Surface Roughening

Source: www.rocklandmfg.com

Maintenance

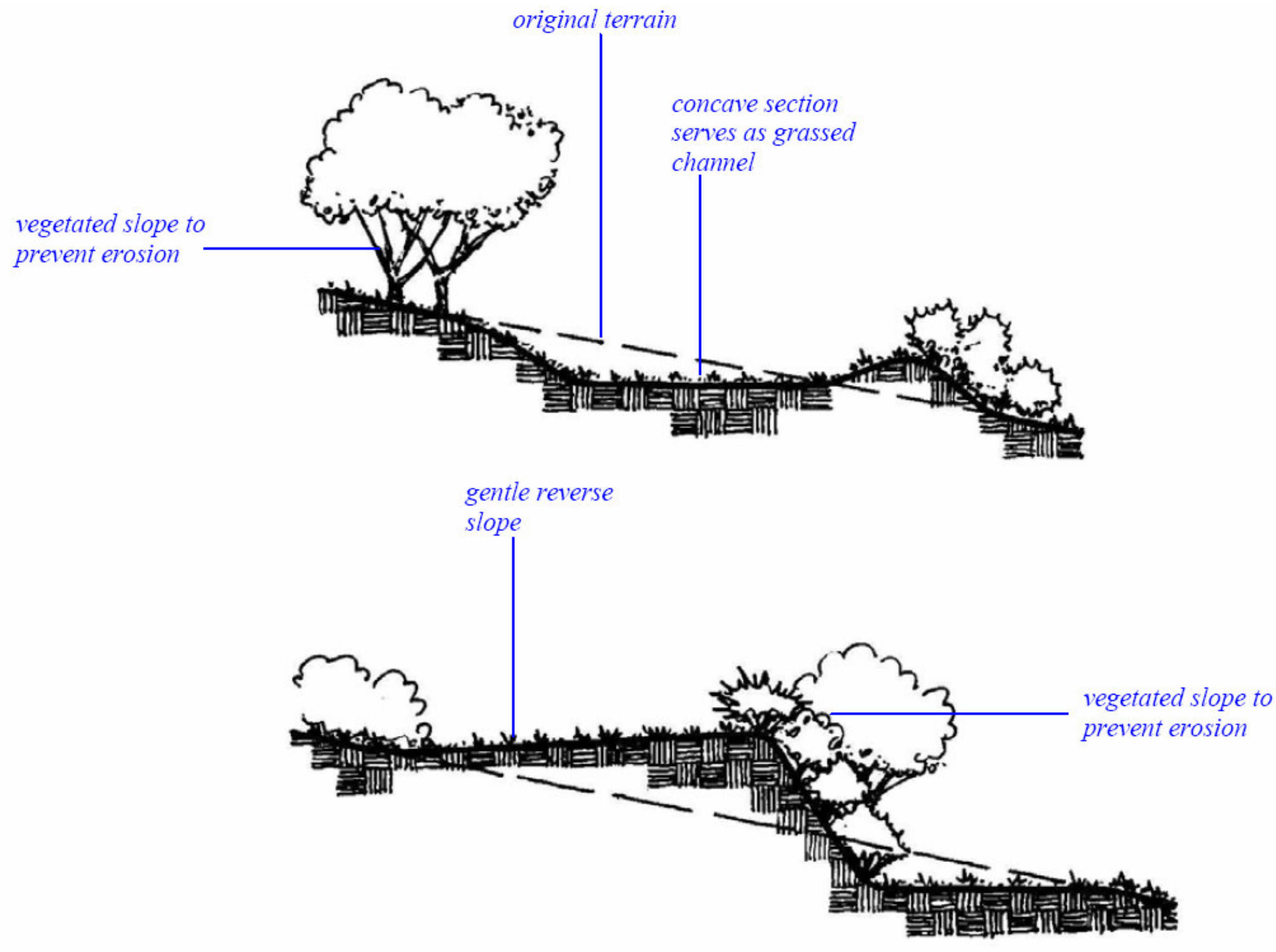
In general, runoff conveyance practices should be periodically inspected to ensure that they are adequately conveying stormwater runoff and that there are no signs of erosion or unexpected surface ponding. Maintenance activities commonly include; repairing eroded gullies, replanting damaged vegetation and removing accumulated sediment and debris.

Plans & Specifications

Plans & specifications for LID runoff conveyance practices shall be in accordance with this guidance document and other reputable sources such as the Prince George's County, MD Bioretention Manual. At a minimum, the following information should be submitted:

1. A site plan that identifies the proposed LID runoff conveyance practice, contributing drainage area, site slope and soil type
2. Design calculations (as applicable)
3. Construction details (as applicable)
4. Planting schedule (as applicable)

Figure 6-2 – Check Dam & Terrace Diagram



Source: Prince George's County MD, Department of Environmental Resources

VEGETATED SWALE

Definition

Vegetated swales are open channel treatment practices that are designed to treat stormwater runoff. As stormwater runoff flows through a vegetated swale, it is filtered by the vegetation in the swale and/or infiltrated into the underlying soil media. There are several variations of the vegetated swales, including: the dry swale, wet swale and the grass channel all of which are basic improvements on the traditional drainage ditch.

Dry swales are essentially linear filtering systems which incorporate an engineered soil bed and underdrain system beneath the channel. Wet swales rely on wetland vegetation to provide water quality treatment to runoff flowing through the swale. Grass channels are the most similar to traditional drainage ditches, but are designed to generate a relatively slow flow velocity to facilitate water quality treatment of small but frequent storm events.

Purpose

Vegetated swales provide water quality treatment to collected stormwater runoff by various factors including filtration, settlement and plant uptake. Dry swale and grass channel design variations can also provide groundwater recharge. When runoff is infiltrated to groundwater, the rate and volume of water leaving the site becomes similar to pre-development conditions. Vegetated swales are not appropriate for providing water quantity treatment for relatively large storm events.

Conditions Where Practice Applies

Vegetated swales are commonly implemented along roadway and sidewalk corridors, and within residential developments. Such systems require relatively flat surfaces and are not effectively constructed at longitudinal slopes greater than 4%. Wet swales have the potential for standing water and should be sited as applicable. Dry swales and grass channels should be sited where underlying soils are moderately permeable and in areas that do not receive surface runoff from land uses that can generate excessive stormwater pollutants (e.g. near fueling stations, chemical storage areas, etc.). Common applications of the grass channel are as pretreatment to other structural stormwater treatment practices and as primary treatment for rooftop runoff. Vegetated swales are normally designed and implemented to effectively treat the runoff from drainage areas less than 5 acres in size.

Source: University of Connecticut

Design Criteria

Pretreatment of stormwater runoff prior to discharging into an open channel treatment swale is typically accomplished by a combination of forebays, pea gravel diaphragms and gently sloping channel sides. Vegetated swales are designed to have non-erosive peak runoff velocities for the 1-year storm event, be able to safely convey the 10-year storm event without overtopping and have temporary ponding for a maximum of 40 hours.

Stormwater quality treatment is provided by volume based surface ponding within the wet and dry swale design variants. Grass channels are sized to provide water quality treatment based on relatively slow runoff flow rates and must be sized to provide an average residence time of 10 minutes, a velocity no greater than 1 ft/second and a water depth of no more than 4-inches for the water quality rainfall event of 0.9-inches.

The Vermont Stormwater Management Manual (VSWMM) contains a comprehensive description of required elements, design guidance and a construction inspection checklist for vegetated swales. **Figures 6-3, 6-4** and **6-5** are illustrations of a dry swale, wet swale and grass channel, respectively, put forth within the VSWMM.

Maintenance

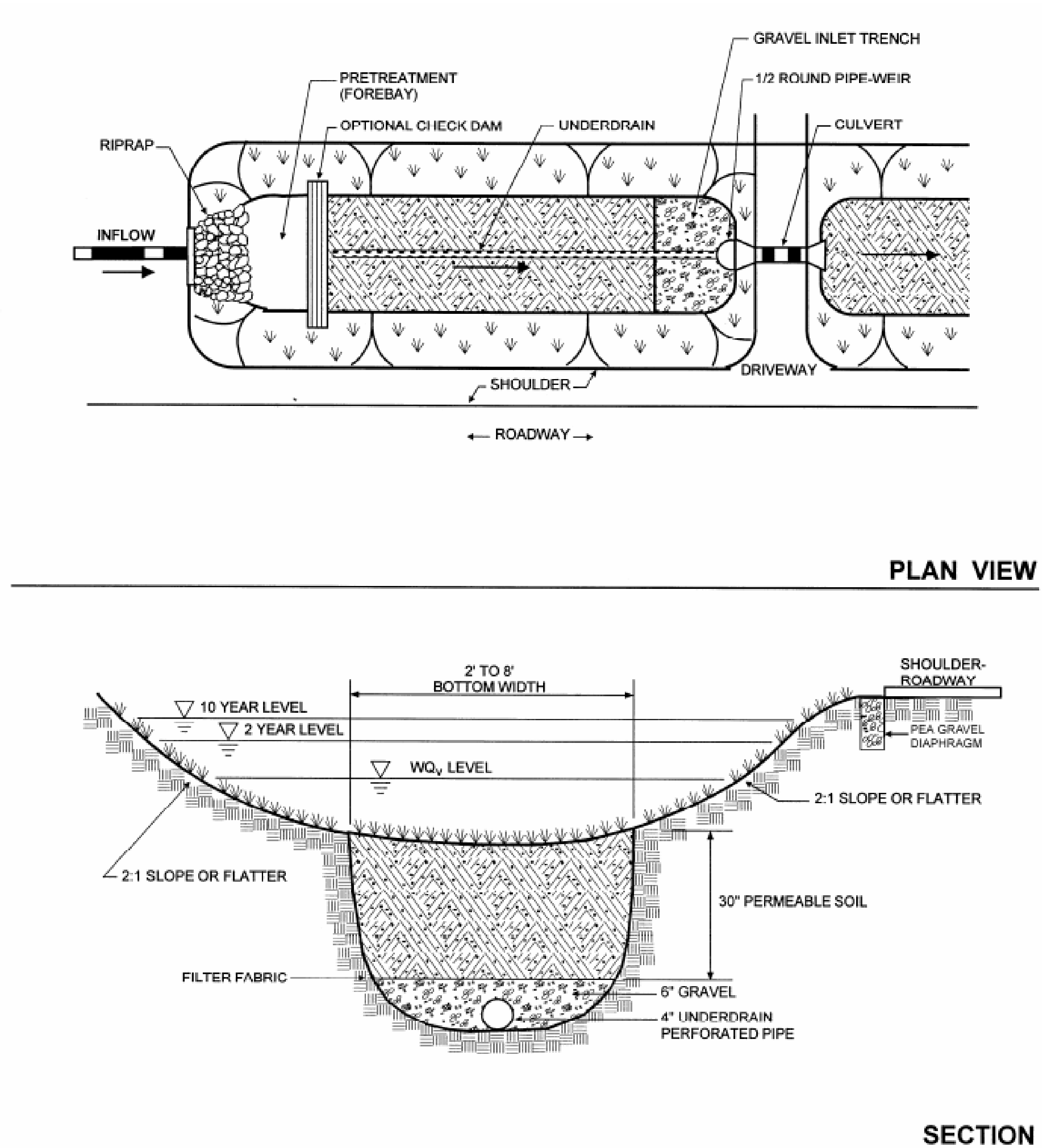
Annual inspections shall ensure the successful establishment of vegetative cover and that the system is free of accumulated debris. Grass within treatment swales should be mowed at least twice during the growing season to maintain a height of 6 inches. Erosion gullies should be repaired and accumulated sediment removed as necessary. Dry swales can periodically require cultivating of the channel bed in order to increase the permeability of the system. The VSWMM contains an operation, maintenance and management inspection checklist for vegetated swales.

Plans & Specifications

Plans & specifications for constructing and installing open channel treatment swales shall be in accordance with this guidance document, local land development regulations and the Vermont Stormwater Management Manual. Submitted information should demonstrate that all design requirements of the treatment practice are met. At a minimum, the following information should be submitted:

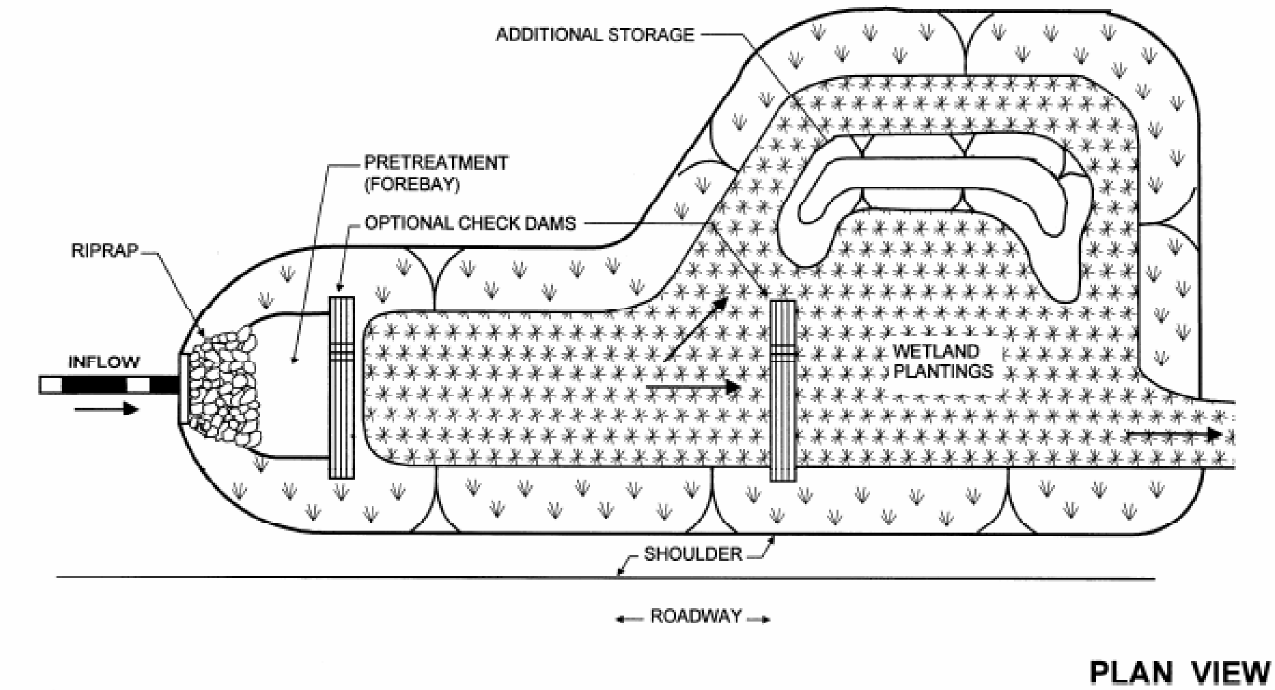
1. Site information including but not limited to: contributing drainage area, land use, slope and soil type
2. Design calculations
3. Construction detail and sequencing plan
4. Maintenance plan

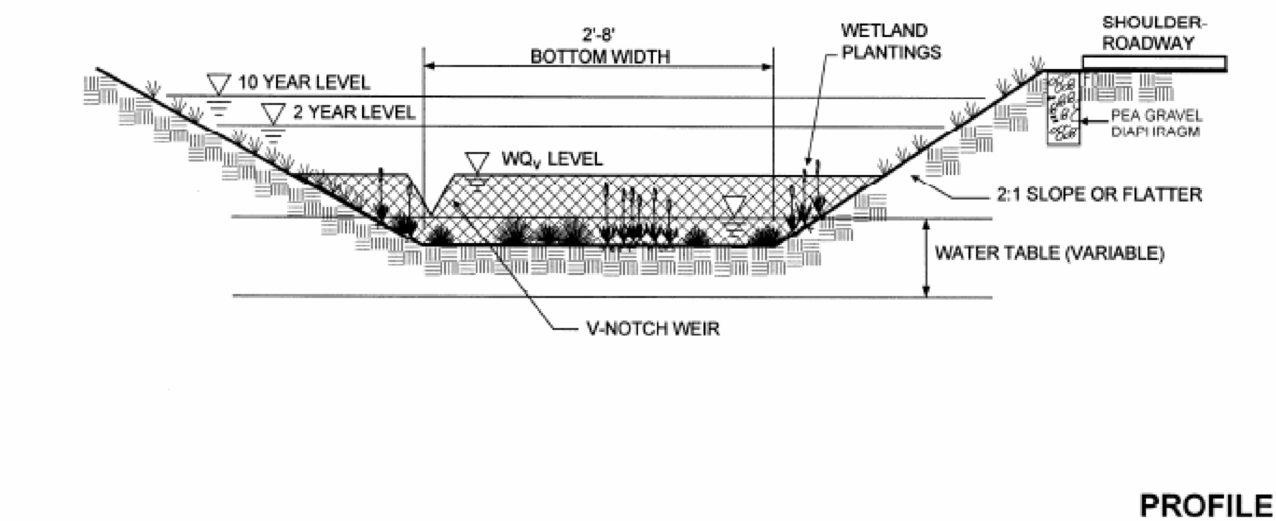
Figure 6-3 – Dry Swale



Source: Vermont Stormwater Management Manual

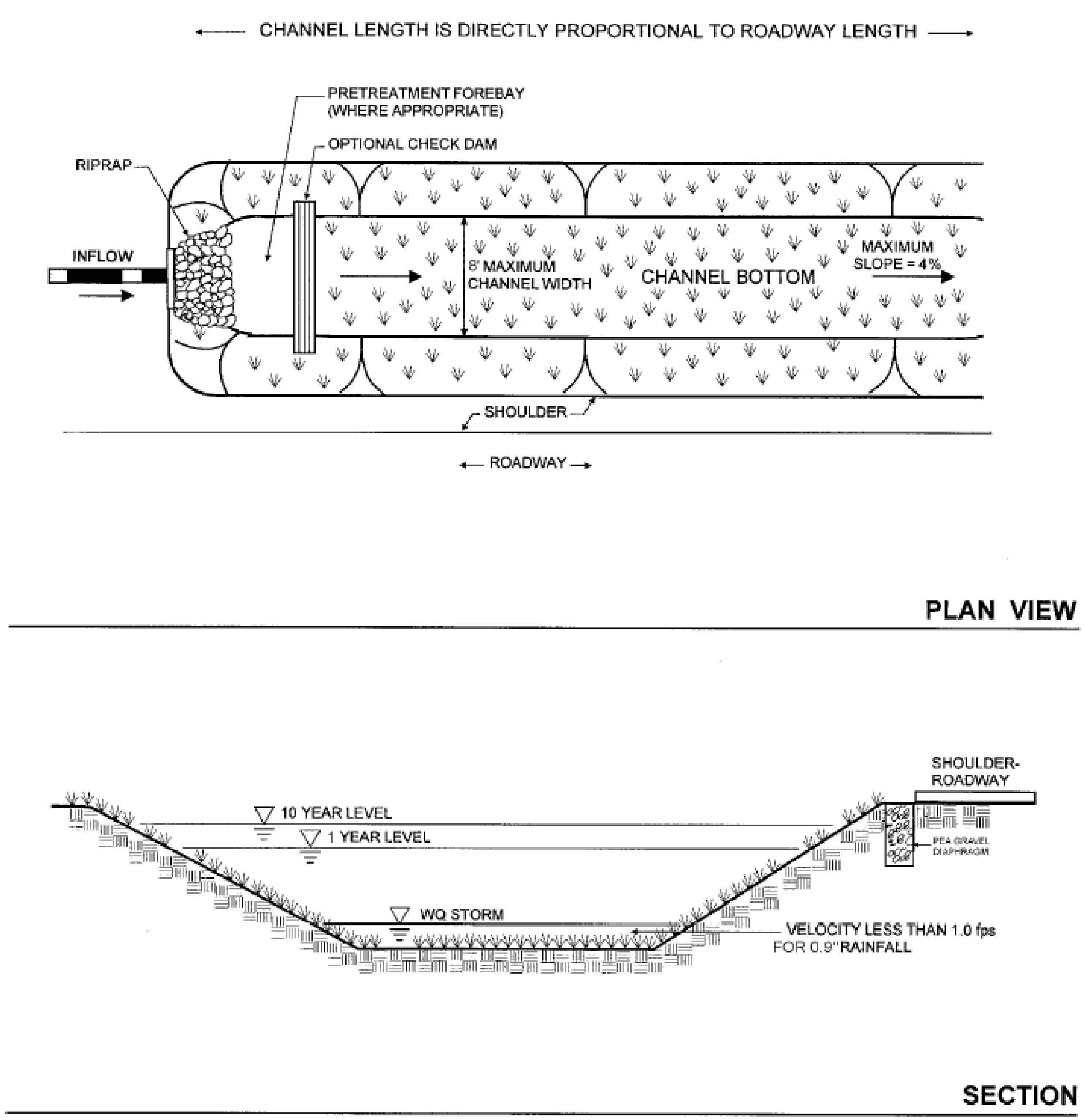
Figure 6-4 – Wet Swale





Source: Vermont Stormwater Management Manual

Figure 6-5 – Grass Channel



Source: Vermont Stormwater Management Manual

SECTION 7

RUNOFF STORAGE PRACTICES

GREEN ROOF

Definition

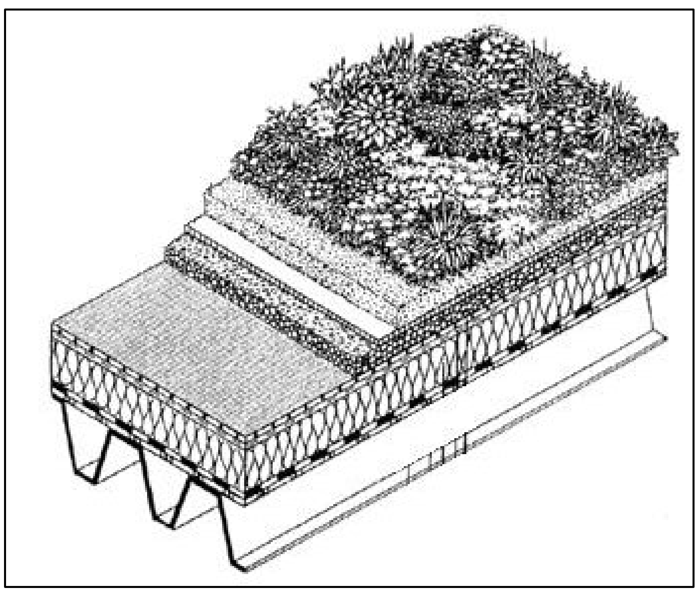
Green roofs consist of a layer of vegetation and soil installed on top of conventional building roofs. Precipitation that falls onto a green roof is absorbed by rooftop vegetation and is ultimately conveyed into the atmosphere through evapotranspiration. Due to this process, green roofs generate lower stormwater runoff volumes and flow rates then traditional rooftops. Green roofs can be categorized as "intensive" or "extensive", depending on the depth of planting medium and the amount of maintenance they require. Intensive green roofs have a relatively deep soil layer, significant maintenance requirements, and high capital costs. Extensive green roofs have a thin soil layer, minimal maintenance requirements, and lower capital costs. Green roofs are also commonly referred to as eco-roofs, vegetated roofs and living roofs.

Purpose

Green roofs effectively reduce impervious coverage while maintaining adequate and functional rooftops. The implementation of green roofs assists in maintaining pre-development hydrologic characteristics and reduces the amount of stormwater runoff generated onsite and associated downstream demands. In addition, green roofs can improve air quality, attenuate noise, increase energy efficiency, moderate temperatures and improve aesthetics.

Conditions Where Practice Applies

Green roofs are appropriate for a wide variety of building types including those with flat and sloped roofs. This practice is commonly effective in highly urbanized areas where traditional rooftops make up a large portion of the impervious coverage. Green roofs can be incorporated into new building designs and redevelopment projects of various sizes ranging from small single structures to large multi-structure complexes.



Source: Roofscapes, Inc.

Design Criteria

Green roofs are generally comprised of the following components: roof structure, waterproofing membrane, drainage layer, growth medium and vegetation. It is critical that design consideration be given to the load bearing capacity of a roof structure prior to construction of a green roof system. Factors such as construction materials, stormwater storage and potential pedestrian traffic should be considered when performing a load bearing analysis. Stabilization measures are often needed on sloped roofs to secure green roof system components. Waterproof membranes, such as PVC liners, are installed above the roof surface and function as a physical barrier between the traditional rooftop and vegetated roof system. The drainage layer commonly consists of aggregate or manufactured material that provides conveyance to structural rooftop storm drain collection components when storage capacity within the porous growth media is exceeded. A light weight, high porosity growth media is generally preferred for green roof applications. Soil depths are typically less than 6-inches for extensive green roofs and greater than 6-inches for intensive green roof systems. Roof top vegetation should consist of native or adapted plants able to withstand local climate conditions.

Maintenance

Maintenance requirements for green roofs are largely dependent upon the type of roof system and specific vegetation. Intensive green roofs have greater maintenance requirements than do extensive systems. Maintenance activities such as watering and fertilizing are commonly greatest during the first few seasons while plants are becoming established. Ongoing maintenance activities can include semiannual weeding and general roof system inspection.

Source: http://apps.carleton.edu/campus/sustainability/greenroof/

Plans & Specifications

Plans & specifications for green roof designs shall be in accordance with this guidance document and other reputable sources such as the Maine Stormwater Best Management Practices Manual. At a minimum, the following information should be submitted:

1. A site plan that identifies the location and dimensions of the green roof
2. Design calculations
3. Construction details
4. Planting plan
5. Maintenance plan

RAIN BARRELS & CISTERNS

Definition

Rain barrels and cisterns are storage structures used to collect and retain stormwater rooftop runoff. Collected and stored stormwater is generally used for landscape irrigation purposes, but can also be used for non-potable uses within a house or building. Rain barrels are smaller than cisterns and commonly range in size from 20 to 100 gallons. Cisterns are larger storage structures and can be designed to store thousands of gallons of rooftop runoff.

Purpose

Rain barrels and cisterns are installed for various reasons including environmental, economic and self-sufficiency. Rain barrels and cisterns provide detention of collected stormwater runoff which allows for settlement of suspended sediment and reduces a site's peak runoff flow rate which consequently reduces the potential for downstream flooding and erosion. Furthermore, reducing the use of potable water for activities such as landscape irrigation helps conserve resources, reduce demand on the public water distribution system, and the associated costs for these services. In areas where water supply is scarce, reuse of collected rainwater is an apparent and practical strategy.

Conditions Where Practice Applies

The practice of rainwater "harvesting" dates back hundreds of years but has gained recent popularity as an effective and practical low impact development practice. The use of rain barrels and cisterns provide for onsite stormwater storage that reduces the need for large scale stormwater treatment facilities that are often expensive and consume valuable land area. These onsite stormwater storage systems are well suited for urban environments due to their relatively small footprint and are often applicable in retrofit locations. Rain barrels are commonly installed by homeowners and do not require excavation, or specific site soil or groundwater table characteristics. Stored runoff is typically used for irrigation purposes, although more complex plumbing designs incorporate water reuse into internal uses such as toilet flushing (cisterns only). Internal non-potable uses are normally cost prohibitive in retrofit locations but can be more readily incorporated into new development projects.

Source: www.ecocitycleveland.org

Design Criteria

Screens should be used to remove debris from rooftop runoff prior to discharging into rain barrels and cisterns. The amount of water that is discharged into a storage structure is a direct function of the size of the contributing rooftop area. One-inch of rainfall will generate approximately 600 gallons of runoff per 1,000 square feet of rooftop area. While a system does not need to be designed to capture all generated rooftop runoff, it must incorporate an overflow mechanism that allows for passage of large storm events and during times when the system is full. Attention should be given to ensure that overflowing runoff does not cause damage to the adjacent building. The intended use of harvested rainwater should also be considered when sizing a storage system.

Rain barrels and cisterns should be designed so that they can be completely drained for maintenance purposes. It is recommended that storage structures be covered and rooftop runoff be diverted into the structure through an adequately sized opening to prevent mosquito breeding. It is often beneficial to elevate storage chambers to provide increased pressure for water reuse purposes. This can be accomplished by positioning a rain barrel on top of a cement block. Rain barrels and cisterns are commonly decorated or shielded with vegetation to enhance their appearance. It is important that rainwater storage systems be taken out of service during periods of cold weather to prevent possible damage due to freezing.

Source: Winooski Natural Resources Conservation District

Although rain barrels and cisterns provide attenuation of collected stormwater they are not formally recognized as an acceptable stormwater treatment practice within the Vermont Stormwater Management Manual (VSWMM). There are many informative internet resources regarding rain barrels and cisterns. One such resource is the City of Portland, Oregon's Office of Sustainable Development (http://www.portlandonline.com/osd) which provides extensive information and links to additional resources regarding rainwater harvesting. **Figures 7-1** and **7-2** are illustrations of typical rain barrels and cisterns, respectively.

Maintenance

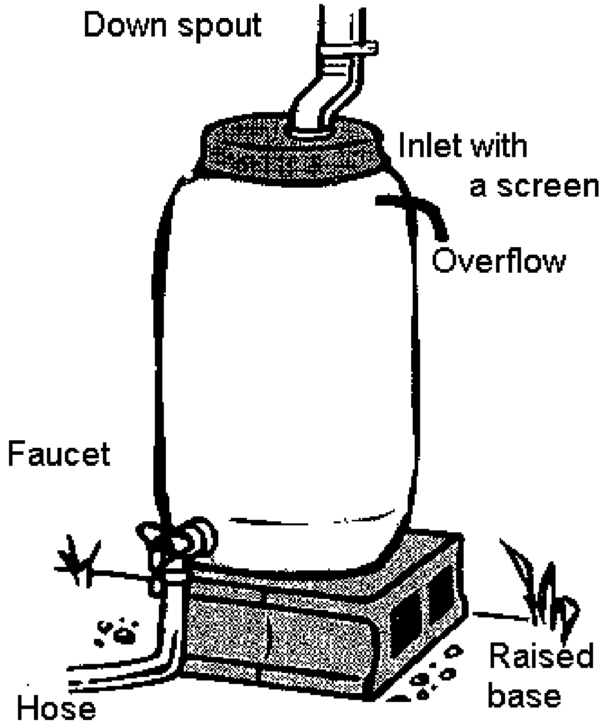
Recommended maintenance activities include periodic inspection and cleaning of rain barrels to ensure that the system is not leaking, breeding mosquitoes or having adverse impacts on the adjacent building due to overtopping. Cisterns may incorporate more complex equipment such as mechanical pumps that may warrant additional inspection and upkeep.

Plans & Specifications

Plans & specifications for constructing and installing a rain barrel or cistern shall be in accordance with this guidance document, and other reputable sources such as the City of Portland, Oregon's Office of Sustainable Development. Submitted information should demonstrate that all design requirements of the practice are met. At a minimum, the following information should be submitted:

1. Contributing rooftop area and storage sizing calculations
2. Rain barrel / cistern detail
3. Installation plan (including management of system overflow)
4. Operation and maintenance plan

Figure 7-1 – Rain Barrel Diagram



Source: www.moriver.org

Figure 7-2 – Cistern Example

Source: www.appropedia.org, Ole Ersson

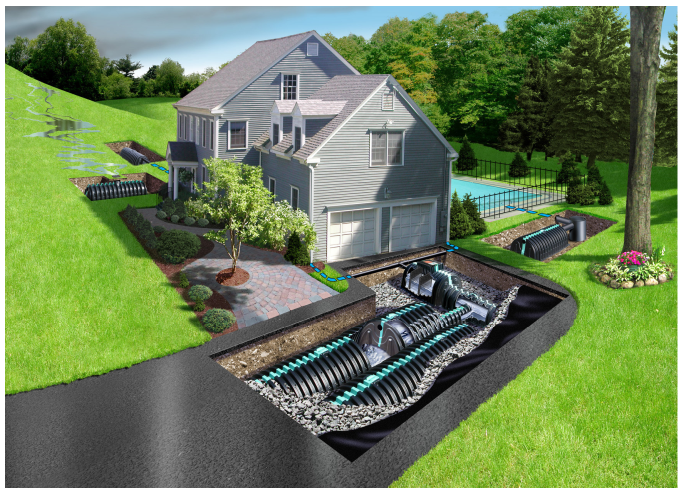
UNDERGROUND STORAGE

Definition

Underground systems allow for the storage and infiltration of collected stormwater runoff beneath the finished grade at a site. Systems are typically constructed of either drainage pipe or prefabricated stormwater storage chambers and surrounded by crushed stone. Stormwater is temporarily stored within an underground system until it infiltrates into the underlying soil media or discharges out of the system through a controlled outlet.

Purpose

Underground systems provide detention and infiltration of collected stormwater runoff while maximizing a site's available land area. Detention of stormwater allows for the settlement of suspended pollutants and reduces the peak runoff flow rates from a site. Collected stormwater is further treated as suspended sediment is filtered out as water infiltrates into the underlying soil media. Infiltrating stormwater recharges groundwater and reduces runoff. When runoff is infiltrated to groundwater, the rate and volume of water leaving the site becomes similar to pre-development conditions.



Source: www.cultec.com

Conditions Where Practice Applies

Underground storage systems have gained popularity throughout the country as land available for traditional surface detention ponds has become increasingly scarce. Underground systems are often used to allow for: efficient land development, the preservation of green space, decreased liability exposure and increased groundwater recharge.

Underground stormwater storage systems are well-suited for urban environments due to their relatively small, yet functional, surface footprint and are typically sited beneath parking areas at commercial, retail and residential developments. If in addition to detention, an underground system is designed to provide infiltration, requirements relating to site soil types, groundwater table characteristics and land use factors are applicable. Underground storage facilities are not appropriate in "hotspot" areas that can generate excessive stormwater pollutants (e.g. near fueling stations, chemical storage areas, etc.) and should not receive sediment laden stormwater in order to prevent premature clogging.

Design Criteria

Stormwater runoff entering an underground storage system commonly discharges into an inlet basin that facilitates preliminary settling of suspended solids and prevents these materials from being deposited further into the system. Access manholes are typically provided above the inlet basin and throughout the system for periodic observation and removal of collected sediment and debris.

Although underground storage systems often provide for the infiltration of stormwater, they are not formally recognized as an acceptable groundwater recharge treatment practice within the Vermont Stormwater Management Manual (VSWMM) at this time. The VSWMM identifies underground storage as a stormwater management practice with limited applicability. Such systems are capable of providing water quantity treatment for drainage areas of varying sizes but are not able to meet water quality and groundwater recharge requirements as stand alone practices. These practices can also be used to deliver collected runoff to either a filter or infiltration area. The use of underground storage systems is encouraged as a component to a stormwater treatment train.

The VSWMM does not provide the same level of detailed discussion regarding the required design elements of underground storage systems as it does for other treatment practices. Although not formally recognized as an acceptable groundwater recharge treatment practice, it is prudent to consider the design considerations set forth for infiltration practices such as; underlying soils need to have an infiltration rate of at least 0.5 inch/hr, a 3-foot separation between the bottom of infiltration structure and the seasonally high groundwater table should be maintained and the facility must not be located within 100 feet of any water supply well. Design specifications for prefabricated storage chambers are often available from the product vendor. **Figure 7-3** is an illustration of a generic underground storage system that is presented in the VSWMM.

Maintenance

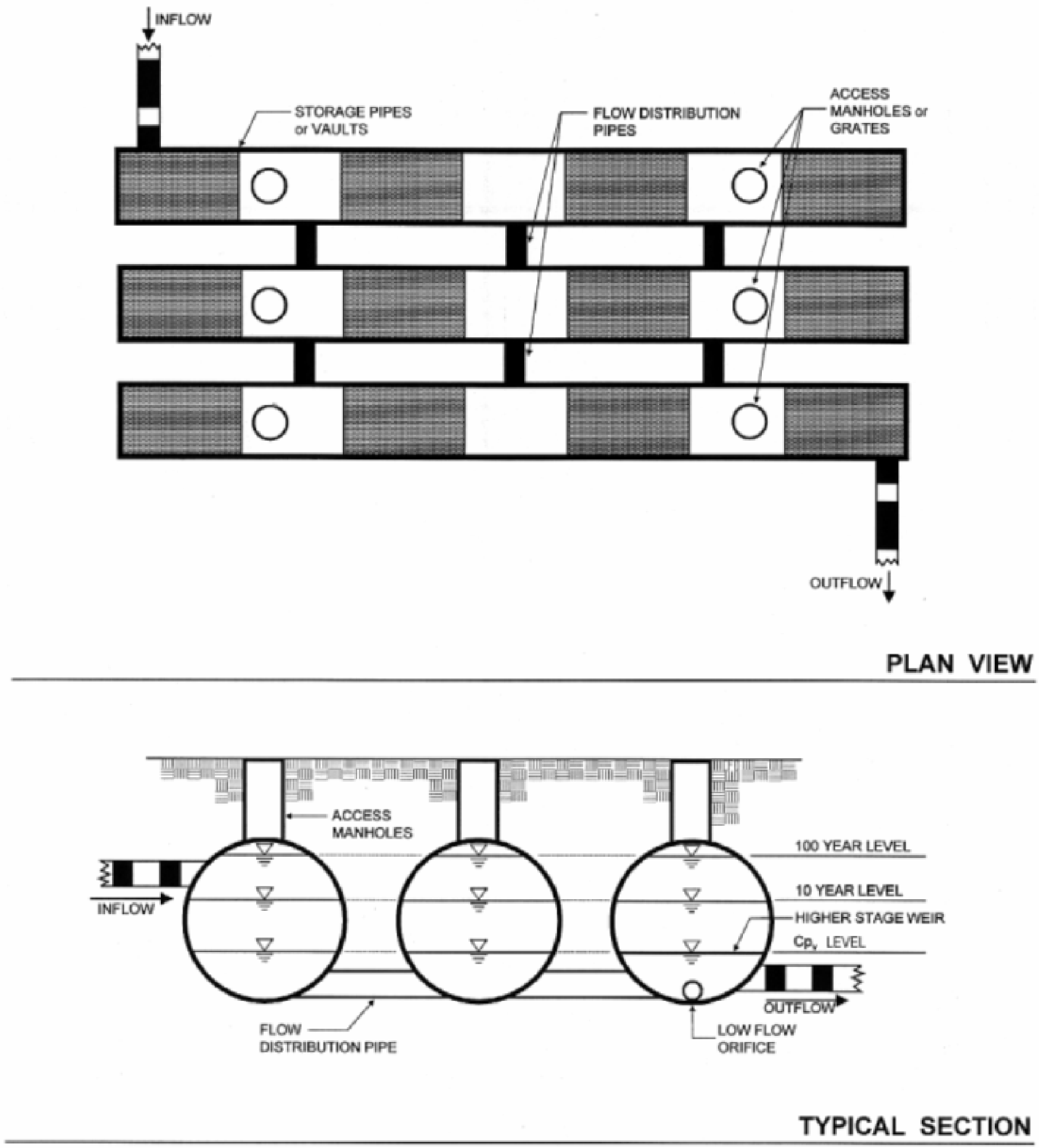
Recommended maintenance activities include system inspection following significant storm events or at least on a semi-annual basis to ensure proper system function, and periodic removal of accumulated sediment and debris by vacuum truck. Recommended maintenance schedules are commonly available by prefabricated storage chamber vendors.

Plans & Specifications

Plans & specifications for constructing and installing an underground stormwater storage system shall be in accordance with this guidance document, the Vermont Stormwater Management Manual and product vendor specifications (if applicable). Submitted information should demonstrate that all design requirements of the treatment practice are met. At a minimum, the following information should be submitted:

1. Site information including but not limited to: contributing drainage area, land use, soil type, infiltration rate and seasonal high groundwater elevation
2. Design calculations
3. Construction detail and sequencing plan
4. Maintenance plan

Figure 7-3 – Underground Storage Facility



Source: Vermont Stormwater Management Manual

SECTION 8

DESIGN EXAMPLES

COMMERCIAL DESIGN EXAMPLE
ABC SAVINGS BANK

Background

The construction of a new ABC Savings Bank is being proposed on a previously undeveloped 1.4 acre site in South Burlington. The new facility will consist of a single story block building, a drive-up teller window with associated parking, driveway and landscaping. The site is bordered by Commercial Street on the north, undeveloped parcels on the west and east, and Bartlett Brook to the south. The project site is currently open meadow and is comprised of Hartland soils (HSG B). Furthermore, the depth to the seasonal high groundwater table is approximately 7.5-feet below ground surface and the average slope of the project site is less than 5%. The Project Team has proposed the following Low Impact Development (LID) practices for the new bank project: a bioretention facility, LID landscaping practices and protection of a vegetative stream buffer. The proposed project is depicted on the attached site plan (**Figure 8-1**) and discussed below.

LID Practices Discussion

Bioretention – The bank parking area and entrance drive will drain to a proposed bioretention facility that will be constructed in the southwest corner of the developed site. Site characteristics such as soil type, depth to seasonal high groundwater and average slope of the contributing drainage area make biorentention an appropriate LID technique for this location. Stormwater runoff will flow through a stone diaphragm prior to discharging into the bioretention facility to ensure non-erosive incoming flow velocities. In accordance with the Vermont Stormwater Management Manual (VSWMM) the facility will be constructed with an engineered soil media that will meet the following criteria:

pH range	5.2 - 7.0
Organic matter	1.5 - 4%
Magnesium	35 lb./ac, minimum
Phosphorus $P2O_5$	75 lb./ac, minimum
Potassium K_2O	85 lb./ac, minimum
Soluble salts	Not to exceed 500 ppm
Clay	10 to 25%
Silt	30 to 55%
Sand	35 to 60%

The bioretention facility will be constructed in a manner that minimizes compaction of the soil media. Moisture tolerant plant species will be planted within the facility in accordance with the following proposed schedule:

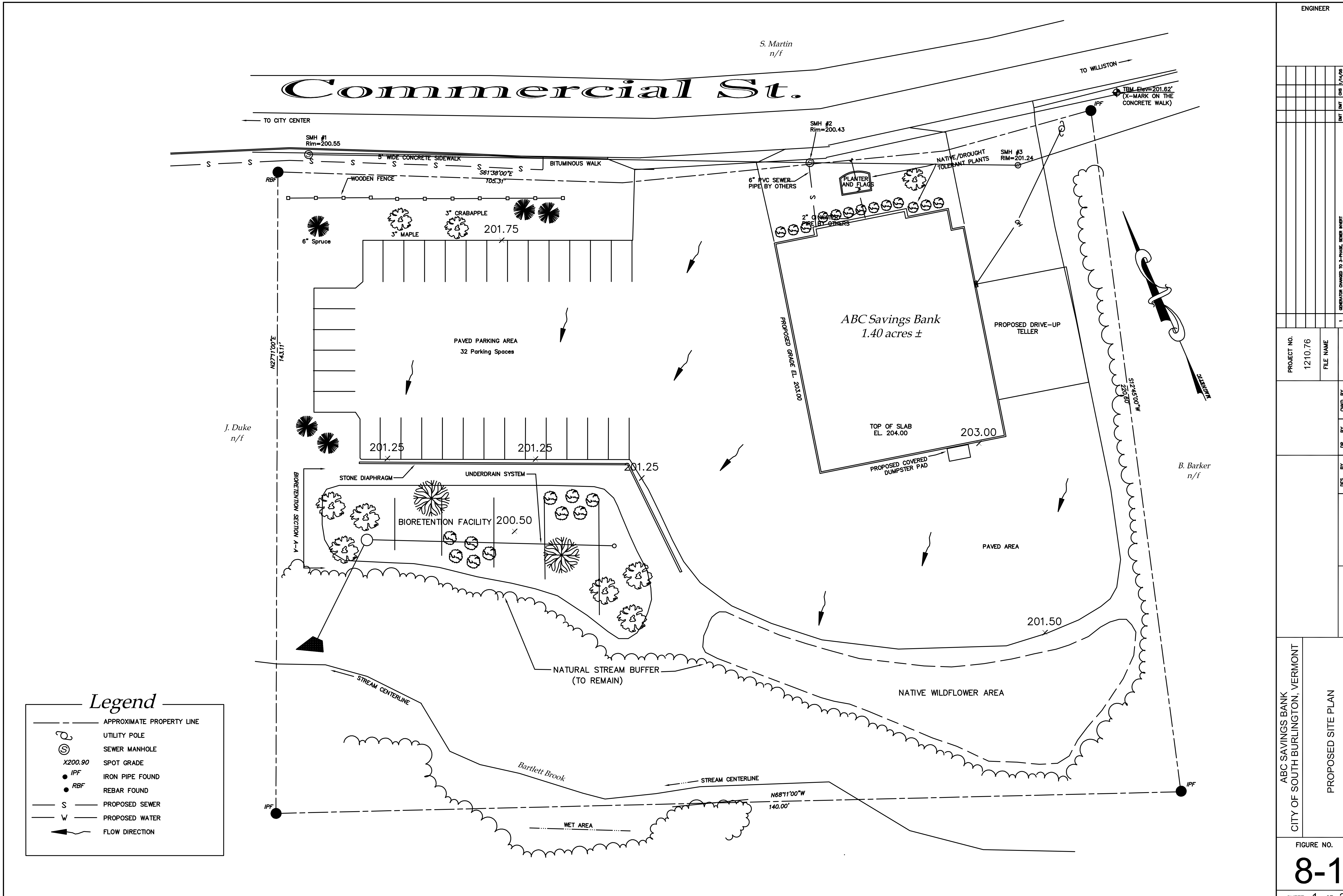
ABC Savings Bank Bioretention Planting Schedule

Code	Scientific Name	Common Name	Size / Caliper	Quantity
AR	Acer rubrum	Red Maple	2.5"-3"	2
CS	Cornus Stolonifera	Redosier Dogwood	18"-24" High	6
LC	Lobelia cardinalis	Cardinal Flower	6"	12
RL	Rudbeckia laciniata	Cutleaf Coneflower	6"	12

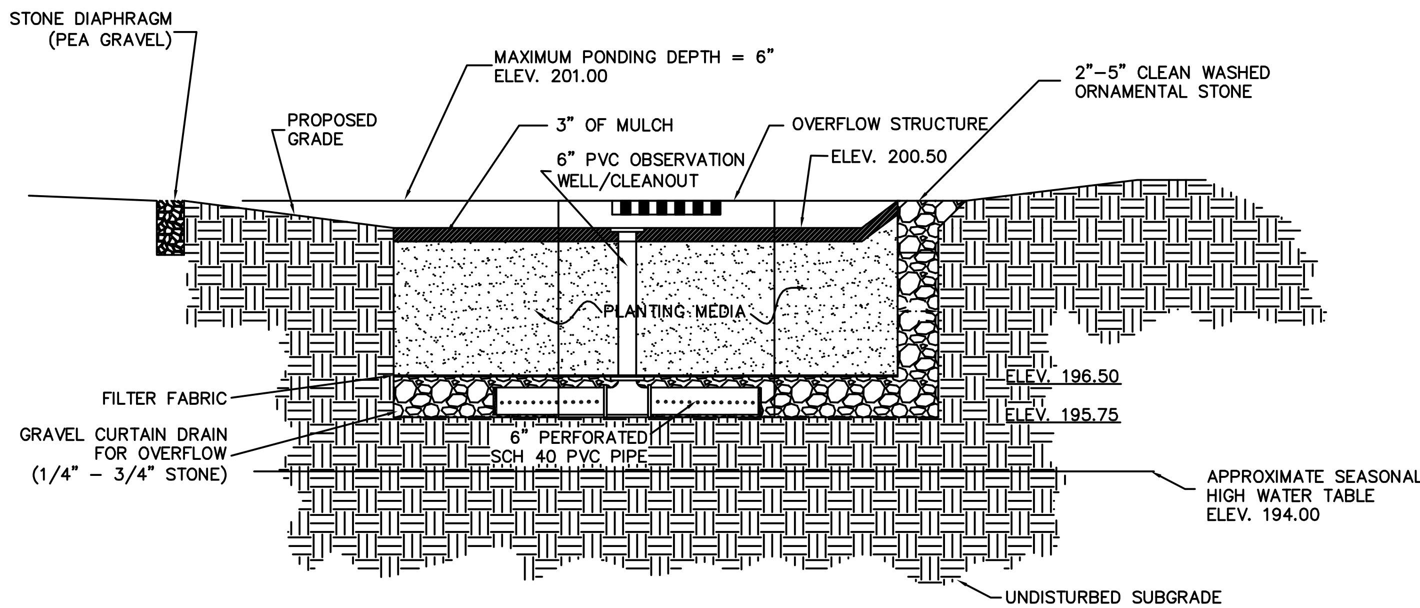
The facility will be mulched with shredded hardwood mulch and will have an overflow structure that will convey runoff from large storm events and discharge to the adjacent stream. In addition, the facility will include an underdrain system to prevent prolonged ponding within the shallow surface depression. A cross section of the proposed bioretention facility is provided on attached **Figure 8-2**.

<u>Landscaping Practices</u> – The ABC Savings Bank landscaping plan incorporates the use of a wildflower meadow rather than turf south of the proposed building and driveway apron. This relatively inexpensive measure enhances opportunities for onsite infiltration and evapotranspiration prior to the runoff reaching the vegetated buffer, improves site aesthetics and reduces ongoing maintenance demands. In addition, the Project Team has planned for native, drought tolerant plants to be planted along the north side of the bank building. These areas will likely require initial application of fertilizer and water, but should require little to no ongoing fertilizing and watering once plants are established.

<u>Vegetative Buffer</u> – The proposed project has incorporated the protection of a vegetative stream buffer that has a minimum width of approximately 50 feet and is located adjacent to Bartlett Brook on the south end of the site. The proposed bank building and associated parking has been sited relatively close to Commercial Street in order to accommodate the protection of the existing vegetative buffer located at the south end of the property. In general, runoff from the parking area, driveway and building rooftop will drain to either the native wildflower area or bioretention facility. Any stormwater runoff that passes through these facilities will eventually flow through the protected buffer area before reaching the adjacent stream. The proposed maximum contributing overland flow path length is 145 feet. The existing vegetation adjacent to Bartlett Brook will be protected from construction related impacts by being clearly identified onsite with orange flagging. Minor impacts to the buffer area will result due to the construction of the outlet pipe for the bioretention facility. Protection of this naturally vegetated corridor will lead to increased stream channel stability in this area.



Commercial St.
S. Martin n/f
TO CITY CENTER
TO WILLISTON
TBM Elev=201.62' (X-MARK ON THE CONCRETE WALK)
IPF
SMH #1 Rim=200.55
SMH #2 Rim=200.43
SMH #3 RIM=201.24
5' WIDE CONCRETE SIDEWALK
BITUMINOUS WALK
S61°38'00"E 105.31'
RBF
WOODEN FENCE
6" PVC SEWER PIPE BY OTHERS
PLANTER AND FLAGS
NATIVE/DROUGHT TOLERANT PLANTS
2" CI WATER PIPE BY OTHERS
OH
3" CRABAPPLE
3" MAPLE
6" Spruce
201.75
PAVED PARKING AREA
32 Parking Spaces
N27°11'00"E 143.11'
J. Duke n/f
ABC Savings Bank
1.40 acres ±
PROPOSED GRADE EL. 203.00
PROPOSED DRIVE-UP TELLER
TOP OF SLAB EL. 204.00
203.00
PROPOSED COVERED DUMPSTER PAD
S12°45'00"W 220.80'
B. Barker n/f
201.25
201.25
201.25
STONE DIAPHRAGM
UNDERDRAIN SYSTEM
BIORETENTION SECTION A-A
BIORETENTION FACILITY
200.50
PAVED AREA
201.50
NATURAL STREAM BUFFER (TO REMAIN)
NATIVE WILDFLOWER AREA
STREAM CENTERLINE
Bartlett Brook
STREAM CENTERLINE
N68°11'00"W 140.00'
WET AREA
Legend
APPROXIMATE PROPERTY LINE
UTILITY POLE
SEWER MANHOLE
X200.90 SPOT GRADE
IPF IRON PIPE FOUND
RBF REBAR FOUND
S PROPOSED SEWER
W PROPOSED WATER
FLOW DIRECTION
ENGINEER
1 GENERATOR CHANGED TO 3-PHASE, SEWER INVERT
REV. DESCRIPTION
PROJECT NO. 1210.76
FILE NAME
DO NOT SCALE DRAWING
CHKD. BY
DR. BY
DES. BY
DATE: OCTOBER 2008
SCALE: NTS
ABC SAVINGS BANK
CITY OF SOUTH BURLINGTON, VERMONT
PROPOSED SITE PLAN
FIGURE NO.
8-1
SHEET 1 OF 2



SECTION A-A

BIORETENTION FACILITY

NOT TO SCALE

ENGINEER

PROJECT NO. 1210.76

FILE NAME

DO NOT SCALE DRAWING

CHKD. BY

DR. BY

DES. BY

DATE: OCTOBER 2008

SCALE: NTS

ABC SAVINGS BANK
CITY OF SOUTH BURLINGTON, VERMONT

SECTIONS & DETAILS

FIGURE NO.

8-2

SHEET 2 OF 2

RESIDENTIAL DESIGN EXAMPLE
PINE KNOLL TOWNHOMES

Background

A project consisting of thirty-two (32) residential town house units has been proposed for a 24.4 acre lot in South Burlington's South East Quadrant. The proposed residential project, known as Pine Knoll, will include construction of 16 townhouse buildings (two units per building) and all necessary infrastructure including roadway and utilities. The project site is currently undeveloped and consists of a combination of Adams-Windsor (HSG A) and Duane-Deerfield (HSG B) soils. The property is bordered by Dorset Street on the east, residential development on the north and undeveloped property on the west and south. In an effort to reduce the demand for conventional stormwater management infrastructure, the Project Team has proposed the following Low Impact Development (LID) strategies: cluster development, open space preservation, disconnection of impervious area, shared driveways, porous pavement, a bioretention facility and an infiltration basin. The proposed Pine Knoll project is depicted on the attached site plan (**Figure 8-3**) and discussed below.

LID Practices Discussion

Cluster Development – When laying out the proposed residential development, the Project Team sought to concentrate the location of all buildings on the site in order to minimize land development impacts and preserve adjacent open space. This resulted in the proposed building and infrastructure associated with the Pine Knoll development to be located on approximately 10.5 acres out of the total 24.4 acre parcel. The effective development density on the improved portion of the site is roughly 1/3-acre per residential unit. The proposed development configuration results in a reduction in stormwater runoff and lower capital and maintenance costs for associated infrastructure.

Open Space Preservation – Roughly 13.9 acres of the Pine Knoll development have been identified as preserved open space. This area is mostly forested and will not be disturbed during construction. The proposed open space is boarded by land owned by the University of Vermont to the west which contains additional preserved forested lands. The Project Team has prepared a conservation easement for this portion of the site which identifies the allowed uses on this land. Pine Knoll residents will have access to this area for passive recreation activities such as walking and birding. Other benefits of this preserved natural area include; improved onsite stormwater infiltration, reduced air pollution and enhanced noise attenuation.

Disconnection of Impervious Area – The LID practice of "disconnecting" impervious areas relies on the diversion of stormwater runoff to vegetated surfaces thereby allowing for filtration and infiltration in the underlying soil media. All the proposed rooftops located above the "back" half of each Pine Knoll Townhome unit have been designed to meet applicable disconnection requirements outlined in the Vermont Stormwater Management Manual (VSWMM). The maximum contributing rooftop impervious flow path is 65 feet, with a maximum rooftop contributing drainage area of approximately 975 square-feet. The Pine Knoll Townhomes will be constructed on slabs and will be equipped with rooftop downspouts that will discharge to backyard lawn areas with maximum slopes of 5%. In areas where adequate space is available, runoff draining from the "front" half of twenty (20) residential units has also be disconnected. In areas where proper rooftop disconnection is not feasible, site grading will allow for rooftop runoff from twelve (12) units to drain towards the street and eventually to either the center island bioretention facility or infiltration basin via a closed storm drain system.

Shared Driveways – The Project Team has incorporated the use of shared driveways for sixteen (16) of the thirty-two (32) units (see **Figure 8-3**). This strategy is typically used to reduce the total amount of impervious area and associated stormwater runoff generation potential at developed sites. However, since porous pavement has been proposed for all driveways at the Pine Knoll development, the reduction in impervious area and runoff were not the compelling reasons to implement a shared driveway configuration. By utilizing this LID technique, the site was able to accommodate additional residential units on a highly compact footprint. Factors such as parking requirements, turning radii and traffic demands were considered when designing the proposed shared driveways.

Porous Pavement – To further reduce the amount of stormwater runoff generated and demand for associated drainage infrastructure, the use of porous asphalt has been proposed for all residential driveways at Pine Knoll. For this application the Project Team has specified the use of Open Graded Asphalt Friction Course per the Vermont Agency of Transportation Standards and Specifications for Construction. Driveway construction will consist of a uniform graded stone aggregate (24-inches deep) with 40% void spaces topped with an asphalt mixture with the following composition:

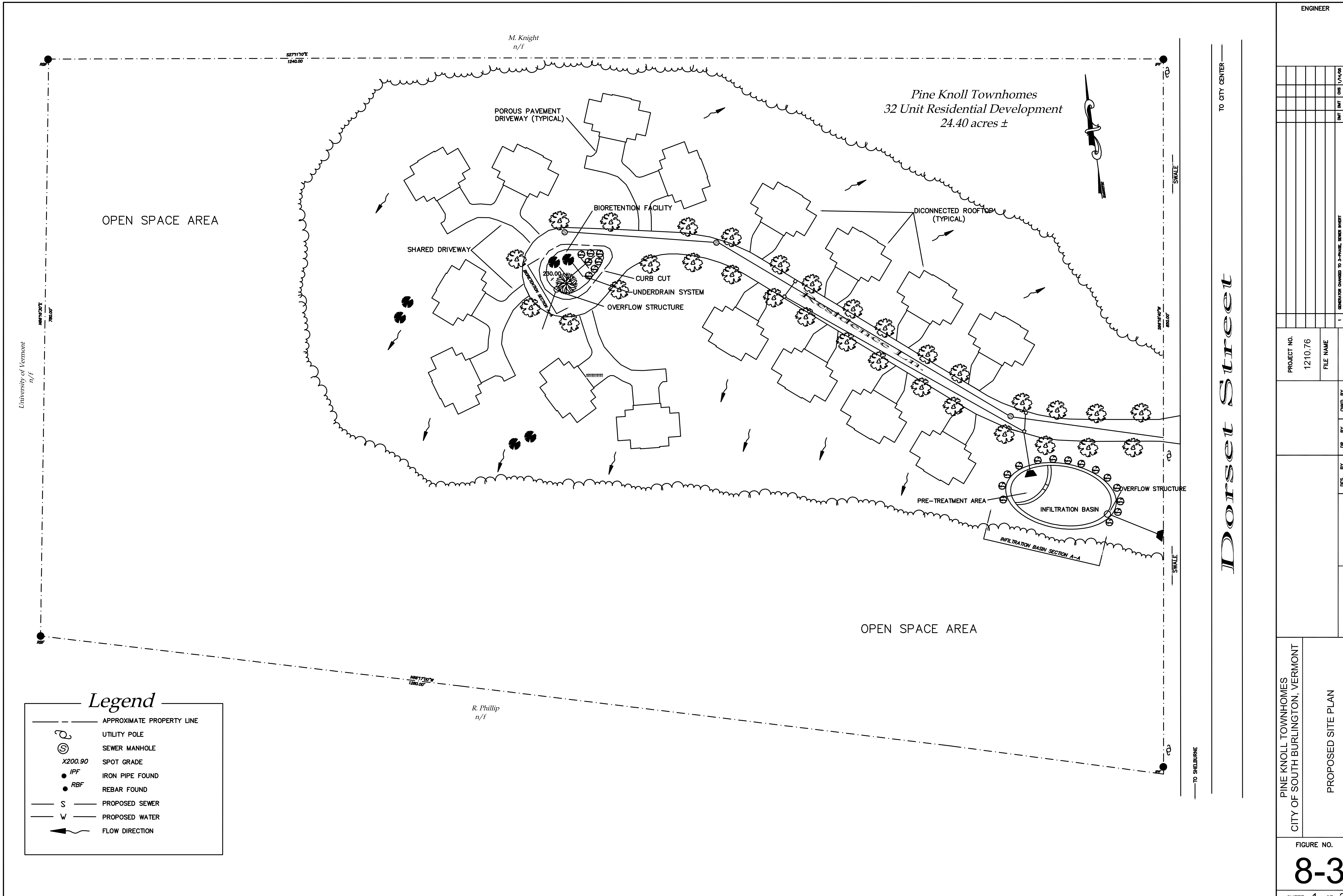
Composition of Driveway Asphalt

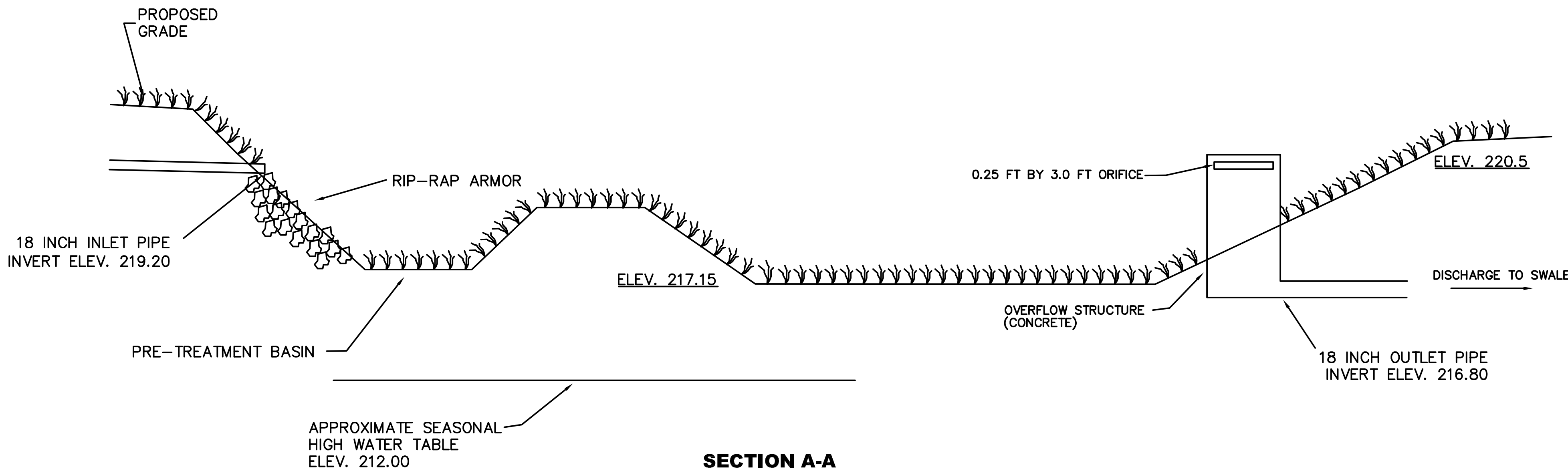
Sieve Designation		Percentage by Mass (Weight) Passing Square Mesh Sieves
Metric	English	
12.5 mm	1/2 inch	100
9.5 mm	3/8 inch	95 to 100
4.75 mm	No. 4	30 to 50
2.36 mm	No. 8	5 to 15
75 µm	No. 200	2 to 5
Total Aggregate		92 to 94.5
Bitumen (% of Total Mix)		5.5 to 8.0

The porous asphalt surface allows precipitation to drain into the underlying stone layer where it is temporarily stored prior to infiltrating into the subsoils. Through the advancement of soil borings throughout the site it has been determined that the maximum seasonal high groundwater elevation is approximately 8 feet below ground surface. In addition, percolation tests have confirmed that the site soils are suitable for infiltration and were observed to have a minimum infiltration rate of 2.25 inch/hour. The driveways will be constructed between May 1st and September 1st following the stabilization of nearby disturbed surfaces. Biannual vacuum sweeping of the driveway surfaces will be incorporated into the Pine Knoll homeowner's association maintenance schedule and budget. In addition to reducing stormwater runoff and increasing onsite infiltration, reported benefits of porous asphalt also include a reduction in required winter maintenance and development of black ice. A typical porous pavement section detail is provided on **Figure 8-4**.

Bioretention Facility – Portions of the roadway and some rooftop area located in the west end of the development will drain to a proposed bioretention facility that will be constructed in the center island. An engineered soil media will be used to filter out suspended sediment and attached pollutants from the contributing stormwater runoff. The facility will include an underdrain system to prevent prolonged ponding within the shallow surface depression. Furthermore, an overflow structure will be constructed to allow for safe passage of runoff from the 10-year and greater storm events. In addition to a cross section of the proposed bioretention facility, the proposed soil media specification and planting schedule are provided on **Figure 8-4**.

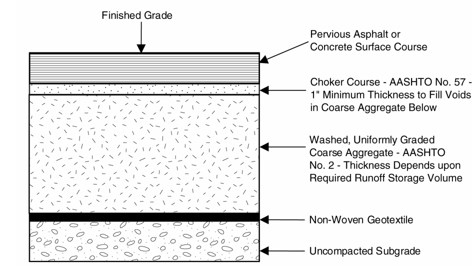
Infiltration Basin – The eastern portion of the roadway and several “front” rooftops will drain to a proposed infiltration basin that will be constructed in the southeast corner of the development footprint. Once again, the Project Team has chosen to take advantage of the site’s relatively high infiltration rates and incorporate a LID measure that relies on infiltration to treat and dispose of collected stormwater runoff. The shallow impoundment has been sited for an area that has a natural slope of approximately 5%. An overflow structure that discharges to a roadside swale has been proposed and is shown on **Figure 8-3**. The infiltration basin is equipped with a pretreatment basin sized to accommodate 25% of the calculated water quality volume. Due to the relatively high infiltration rates, the Team has decided to forego an underdrain manifold. Caution will be taken during and following construction to avoid the discharge of sediment laden stormwater into this facility. A cross section of the proposed infiltration basin is provided on attached **Figure 8-4**.


M. Knight
n/f
S27°11'10"E
1240.00
Pine Knoll Townhomes
32 Unit Residential Development
24.40 acres ±
TO CITY CENTER
POROUS PAVEMENT
DRIVEWAY (TYPICAL)
OPEN SPACE AREA
BIORETENTION FACILITY
SHARED DRIVEWAY
230.00
CURB CUT
UNDERDRAIN SYSTEM
OVERFLOW STRUCTURE
BIORETENTION SECTION
DICONNECTED ROOFTOP
(TYPICAL)
SWALE
Residence Ln.
Dorset Street
University of Vermont
n/f
RBF
IPF
PRE-TREATMENT AREA
INFILTRATION BASIN
OVERFLOW STRUCTURE
INFILTRATION BASIN SECTION A-A
OPEN SPACE AREA
R. Phillip
n/f
TO SHELBURNE
Legend
APPROXIMATE PROPERTY LINE
UTILITY POLE
SEWER MANHOLE
X200.90 SPOT GRADE
IPF IRON PIPE FOUND
RBF REBAR FOUND
S PROPOSED SEWER
W PROPOSED WATER
FLOW DIRECTION
ENGINEER
1 GENERATOR CHANGED TO 3-PHASE, SEWER INVERT
REV. DESCRIPTION
PROJECT NO.
1210.76
FILE NAME
DO NOT SCALE DRAWING
CHKD. BY
DR. BY
DES. BY
DATE: NOVEMBER 2008
SCALE: NTS
PINE KNOLL TOWNHOMES
CITY OF SOUTH BURLINGTON, VERMONT
PROPOSED SITE PLAN
FIGURE NO.
8-3
SHEET 1 OF 2



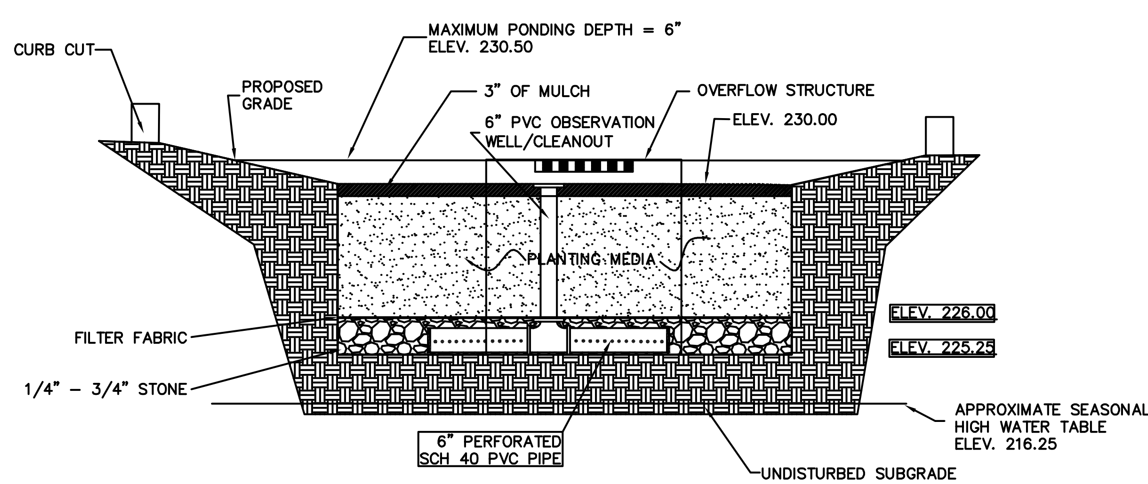
SECTION A-A
INFILTRATION BASIN
NOT TO SCALE

POROUS PAVEMENT DETAIL
SOURCE: NJ DEP, 2004



BIORETENTION PLANTING SCHEDULE

Code	Scientific Name	Common Name	Size / Caliper	Quantity
AR	Acer rubrum	Red Maple	2.5"-3"	1
PR	Pinus rigida	Pitch Pine	2"	2
IV	Ilex verticillata	Winterberry	18"-24" High	7
LC	Lobelia cardinalis	Cardinal Flower	6"	12



SECTION A-A
BIORETENTION FACILITY
NOT TO SCALE

BIORETENTION SOIL MEDIA
SOURCE: MDE, 2000

pH range	5.2 - 7.0
Organic matter	1.5 - 4%
Magnesium	35 lb./ac, minimum
Phosphorus $P2O_5$	75 lb./ac, minimum
Potassium K_2O	85 lb./ac, minimum
Soluble salts	Not to exceed 500 ppm
Clay	10 to 25%
Silt	30 to 55%
Sand	35 to 60%

ENGINEER

REV.	DESCRIPTION	DR. BY	CHKD. BY	APPD. BY	DATE
1	GENERATOR CHANGED TO 3-PHASE, SEWER INVERT	DMT	DMT	CHS	1/14/09

PROJECT NO. 1210.76
FILE NAME
DO NOT SCALE DRAWING
CHKD. BY
DR. BY
DES. BY
DATE: NOVEMBER 2008
SCALE: NTS

PINE KNOLL TOWNHOMES
CITY OF SOUTH BURLINGTON, VERMONT

SECTIONS & DETAILS

FIGURE NO.
8-4
SHEET 2 OF 2

APPENDIX A

LOW IMPACT DEVELOPMENT REFERENCE LIST

Maine Coastal Program, _LID Guidance Manual for Maine Communities, Approaches for Implementation of Low Impact Development Practices at the Local Level_, Horsley Witten Group, September 2007

Metropolitan Area Planning Council, _Massachusetts Low Impact Development Toolkit_, http://www.mapc.org/LID.html

Metropolitan Council Environmental Services, _Minnesota Urban Small Sites BMP Manual, Stormwater Best Management Practices for Cold Climates_, Barr Engineering Co., July 2001

New England Environmental Finance Center, _Promoting Low Impact Development in Your Community_, (#06-05)

Prince George's County, MD, Department of Environmental Resources, _LID Integrated Management Practices Guide_, July 2002

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