ERDC/CERL SR-19-4

Construction Engineering
Research Laboratory

US Army Corps
of Engineers®
Engineer Research and
Development Center

ERDC
ENGINEER RESEARCH & DEVELOPMENT CENTER

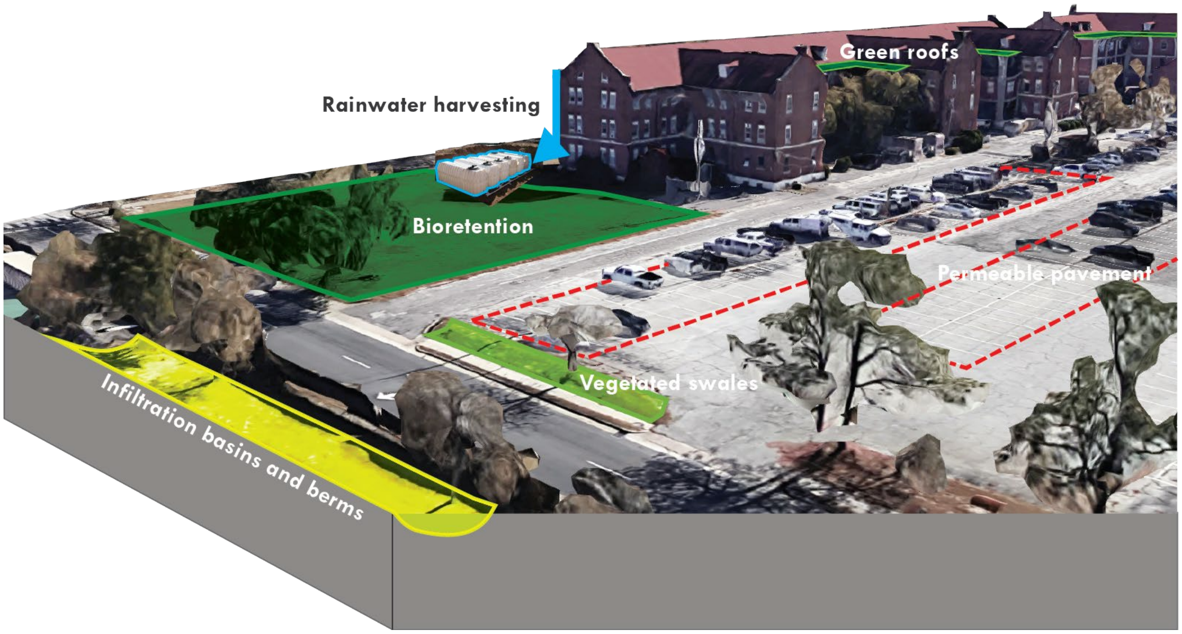
Department of Defense Legacy Resource Management Program

Finding Space:

A Field Guide for Incorporating Low Impact Development into Military Historic Districts

Ellen R. Hartman

September 2019



Department of Defense
Legacy Resource Management Program

ERDC/CERL SR-19-4
September 2019

Finding Space:

A Field Guide for Incorporating Low Impact Development into Military Historic Districts

Ellen R. Hartman

Construction Engineering Research Laboratory
US Army Engineer Research and Development Center
2902 Newmark Drive
Champaign, IL 61822

Final report

Prepared for Department of Defense
Legacy Resource Management Program
4800 Mark Center Drive, Ste 16G14
Alexandria, VA 22350

Under Project 14-752, "Finding Space: A Field Guide for Incorporating LID into Military Historic Districts"

Abstract

The Department of Defense has been tasked by the Energy Independence and Security Act of 2007 and Executive Order 13693, "Planning for Federal Sustainability in the Next Decade," to conserve and protect water resources through increased efficiency, reuse, and management. As a result, sustainable stormwater management strategies are being incorporated throughout the military's built environment to manage stormwater in ways that work with natural hydrologic systems. Collectively, those strategies are called Low Impact Development (LID).

Incorporating LID technologies, or LID BMPs, in designated historic districts requires advanced planning, site analysis, compliance with federal regulations, and coordination between diverse stakeholders. This field guide explains the complex interaction between regulatory requirements and the physical environment to assist cultural resource managers in coordinating with all stakeholders to successfully plan and implement sustainable stormwater management systems.

Contents

Figures

Preface

This study was conducted for the Department of Defense Legacy Resource Management Program under Project 14-752, “Finding Space: A Field Guide for Incorporating LID into Military Historic Districts.” The technical monitor was Ms. Ellen Hartman (ERDC-CERL).

The work was performed by the Land and Heritage Conservation Branch (CNC) of the Installations Division (CN), U.S. Army Engineer Research and Development Center, Construction Engineering Research Laboratory (ERDC-CERL). At the time of publication, Dr. Michael Hargrave was Chief, CEERD-CN-C; Ms. Michelle Hansen was Division Chief, CEERD-CN. The Deputy Director of ERDC-CERL was Dr. Kirankumar Topudurti and the Director was Dr. Lance D. Hansen.

The Commander of ERDC was COL Teresa A. Schlosser and the Director was Dr. David W. Pittman.

Unit Conversion Factors

Multiply	By	To Obtain
acres	4,046.873	square meters
feet	0.3048	meters
inches	0.0254	meters
square feet	0.09290304	square meters
square inches	6.4516 E-04	square meters

1 Introduction

1.1 Background

The Department of Defense (DoD) has been tasked by the Energy Independence and Security Act of 2007 (EISA; U.S. Congress 2007) and Executive Order (EO) 13693, "Planning for Federal Sustainability in the Next Decade," (Obama 2015) to conserve and protect water resources through increased efficiency, reuse, and management. As a result, low impact development (LID) is being incorporated into the military's built environment to manage stormwater near the source, using technologies that work with natural systems. While implementing LID principles and practices in recently constructed areas is a relatively straight-forward process, incorporating sustainable stormwater management strategies in designated historic districts requires more complex advanced planning, site analysis, compliance with the National Historic Preservation Act (NHPA; U.S. Congress 1966), and coordination between diverse stakeholders such as Cultural Resources Managers (CRMs), State Historic Preservation Offices (SHPOs), and Directorate of Public Works (DPW) personnel. For LID strategies to be successfully implemented into a historic district, they not only need to efficiently manage stormwater, but also these technologies need to synthetically blend into the historic landscape characteristics of the site. The perception that sustainable stormwater management technologies are not historically compatible often will serve as a limitation to implementing LID in historic areas. As the DoD continues to adopt more sustainable practices, rethinking stormwater management within historic districts becomes a higher priority.

LID is one of several green infrastructure strategies that addresses sustainable stormwater management. The LID strategy shares the following goals (Dain-Owens and Hartman 2012, E-4–E-5):

- Reduced and delayed stormwater runoff volumes
- Enhanced groundwater recharge
- Stormwater pollutant reductions
- Reduced sewer overflow events
- Increased carbon sequestration
- Urban heat island mitigation
- Improved air quality

- Added wildlife habitat and recreational space
- Improved human health
- Increased land values

While all green infrastructure concepts are closely aligned,[*] the specific aim of LID is to allow for "full development of the property while maintaining the essential site hydrologic functions" (U.S. Environmental Protection Agency [EPA] 2008). To assist with that goal, this work focuses on the LID BMPs that are outlined in the *Army Low Impact Development Technical User Guide* (U.S. Army Corps of Engineers [USACE] 2013); however, installation personnel should be aware that other effective strategies also have been developed to sustainably manage rain events.

This field guide provides DoD CRMs with the basic concepts of LID to facilitate the integration of LID into historic districts by using the guidance outlined in "Army Stormwater Management Using Low Impact Development" (DA 2013) and Public Works Technical Bulletin (PWTB) 200-1-118, *Implementing Sustainable Water Management Strategies in Historic Districts* (Dain-Owens and Hartman 2012). The Army's LID guidance addresses many aspects of creating LID best management practices (BMPs), incorporating LID planning into the master planning process, and implementing LID strategies throughout installations. The PWTB provides a general introduction to basic LID technologies, presents historically compatible construction materials, and discusses various case studies and lessons learned from LID implementation at several military historic districts. Nevertheless, both Army LID guidance and the PWTB lack advice on how to translate that information toward more effective site planning and water management in historic districts. Understanding how to develop LID strategies that account for the more stringent management requirements of a designated historic district helps facilitate more effective communication and planning between CRMs and DPW personnel.

---

[*] The U.S. EPA has more information on the concept of green infrastructure, available at: http://water.epa.gov/infrastructure/greeninfrastructure/gi_what.cfm

1.2 Objective

Field guides are tools for identification. This work's objective was to design a field guide that would assist installation personnel in identifying and managing how the common BMPs used in LIDs could work to manage stormwater, particularly in historic districts.

1.3 Methodology: Using this field guide

Because of the variety of historic districts at military facilities and their potential for unique management issues, this field guide discusses historic districts according to general land-use types. For example, the landscapes of sites built during the Antebellum, World War I (WWI), Interwar, and World War II (WWII) periods can be described generally as clusters of administrative, residential, utilitarian, recreational, and ceremonial land-use areas. After a historic district has been identified for a LID BMP, the site's official period of significance and historic context informs the design and material choices used to construct the LID BMP.

The methodology with which this guide was developed will inform its use. First, a background of LID use is provided. Second, each LID BMP is explained according to its hydrologic functioning. Finally, the guide identifies how that technology can be integrated with the character of a historic district.

With the information gained through this guide, CRMs will be able to effectively coordinate with Environmental and DPW personnel to plan efficient, compatible stormwater management systems in a historic district.

2 Overview of LID

2.1 Basics for general LID use

Low impact development is a concept in water management that aims to address rainwater by using methods that replicate natural hydrology to reduce or eliminate water flowing directly into storm sewers. Impervious surfaces in the built environment negatively impact the hydrological cycle. Water flowing across hard surfaces contributes to erosion, sedimentation, habitat loss, and degrades water quality. LID manages stormwater runoff at the site by using soft infrastructures that are designed for water storage, infiltration, and/or evaporation. Instead of rapidly transporting stormwater from a site, LID promotes stormwater retention and views stormwater as a valuable resource (DoD 2015, 1).

Located strategically, LID BMPs can make a significant contribution to the water quality discharging from a site. However, LID BMPs must be strategically located and designed to work with the environmental conditions of the site. Individual LID BMPs can make a significant impact on water quality but to be most effective, a network of these technologies should be planned in conjunction with site hydrology and then systematically arrayed across an area (DoD 2015, 1).

Incorporating hydrologic planning on a large scale and then integrating LID BMPs into smaller projects will provide environmental, economic, and social benefits. Nevertheless, to maximize the benefits of LID, stakeholders must understand the impacts that the built environment has on the hydrologic functions of a site and on the greater watershed (DoD 2015, 1).

There are four guiding principles of LID (USACE 2013, 1-3):

1. Maintain predevelopment hydrologic system functions on the site, including infiltration, evaporation, and transpiration.
2. Preserve drainage patterns and watershed timing.
3. Employ nonstructural planning practices to minimize the impacts of development.
4. Locate LID BMPs strategically across an area to achieve hydrologic goals.

The hydrologic cycle is the continuous circulation of water between the atmosphere and the earth through precipitation, evaporation, and evapotranspiration. The hydrologic cycle is affected by the climatological and environmental conditions of a region and functions differently across the country.* In the hydrologic cycle, LID addresses the water from precipitation that has not evaporated, collected, infiltrated, or transpired. This excess water is called runoff, which can occur as overland flow, subsurface flow, saturated overland flow, and it occurs in areas with high proportions of impervious surfaces.

LID BMPs are categorized into two main components: nonstructural practices and structural practices. Nonstructural practices are large-scale planning and design strategies that minimize the amount of stormwater runoff that occurs within a development. Structural BMPs are smaller-scale interventions that are designed and constructed to directly manage a particular site's stormwater volume, velocity, and quality after runoff appears. Both practices maintain or reintroduce hydrologic system functioning to a site (USACE 2013, 1-3).

Nonstructural LID BMPs focus on minimizing the impacts of stormwater runoff across a site. Often, nonstructural LID practices are integrated into the master planning process. Thus with new development, nonstructural practices are prioritized over the implementation of structural BMPs (USACE 2013, 2-11).

Structural LID BMPs work by collecting and slowing runoff from impervious surfaces. Runoff (also described as sheetflow), can carry nonpoint source pollution, excessive sediment, and debris that LID BMPs are designed to address (USACE 2013, 2-26).

2.2 Basics for LID use in historic districts

Consequently, structural LID BMPs used in built environments such as historic districts must be located near and associated with roads, parking lots, sidewalks, roofs, and other impervious surfaces to direct sheetflow into the LID system for management.

---

* More information on the hydrologic cycle and earth's water resources is available at http://water.usgs.gov/edu/watercycle.html.

Because historic districts are established built environments, employing both nonstructural and structural LID practices provide benefits. Developing an overall hydrologic master plan that leverages nonstructural LID practices is an important component that helps guide the placement of future structural BMPs. However, as developed sites, historic districts will likely gain the most positive impacts from well-sited and integrated structural BMPs.

As previously stated, PWTB 200-1-118, *Implementing Sustainable Water Management Strategies in Historic Districts*, provides a comprehensive overview of sustainable stormwater management in historic districts (Dain-Owens and Hartman 2012).

3 Nonstructural LID BMPs in Historic Districts

Nonstructural LID practices are site-level planning strategies. The primary goal of nonstructural BMPs is to incorporate hydrologically focused strategies into the master planning process. With hydrologic planning, the impacts of development on the watershed are reduced before construction begins, in an effort to eliminate the need for smaller-scale, more costly structural LID BMPs to be installed after site development (USACE 2013, 2-11).

Nonstructural BMPs are typically planning-phase considerations, but they can be implemented in both predeveloped and developed sites. Integrating nonstructural BMPs within a historic district's landscape maintenance plan is a long-term step to reducing the impacts of development on the hydrologic cycle.

The goals of nonstructural BMPs are to limit the boundaries of development and maintain site-wide hydrologic functioning by (USACE 2013, 2-11):

- preserving natural water flow pathways and patterns
- protecting sensitive areas that have high habitat value and function
- protecting riparian buffer areas
- site fingerprinting
- minimizing soil compaction
- minimizing the total disturbed area
- clustering development
- reducing impervious surfaces

Because nonstructural BMPs are longer-term, larger-scale planning factors, they are summarized here to provide a comprehensive understanding of how LID BMPs work to preserve or reestablish a site's natural hydrologic system. When practical, these strategies should be incorporated into a long-term historic district management plan.

Nonstructural LID BMPs can be divided according to two general classifications: one dealing with environmental considerations, and the other addressing construction procedures. Nonstructural environmental LID

BMPs are strategies for reestablishing hydrologic functioning, while the construction focused LID BMPs aim to minimize the impacts of construction across a site.

For more information on using LIDs in Army construction, see Low Impact Development in Army Construction (Young and Deliman 2012).

3.1 Environment-focused LID BMPs

The following sections expand on the environmental goals of LID BMPs.

3.1.1 Preserve natural flow pathways and patterns

Natural flow patterns are determined by site topography, which should be preserved during and after construction. Topographic features that aid the hydrologic cycle are areas of sheetflow, depressions for storage, existing grades, and ditches or channels. Maintaining flow patterns positively affects peak discharge rates and runoff volumes while reducing erosion (USACE 2013, 2-13 and 2-14).

Preserving natural flow patterns can be integrated into most development projects, with the exception of those in ultra-urban environments with existing stormwater infrastructure. To be most effective, preserving flow patterns should be a component of the predevelopment site planning phase (ibid.).

3.1.2 Protect sensitive areas

Sensitive areas are natural areas with a high ecological value, and they include critical habitats, water supplies, riparian buffers, wetlands, steep slopes, woodlands, and areas with cultural significance. Avoiding impacts to those sites protects ecological functioning and natural hydrologic systems (USACE 2013, 2-17). Sensitive areas must be identified so that those sites can be properly delineated and avoided during construction.

3.1.3 Protect riparian buffer areas

Riparian buffers are vegetated strips along streams that protect the waterway from adjacent land uses, nonpoint source pollution, and bank erosion.

Buffers can be natural or reestablished and should contain a mix of vegetation that includes trees, shrubs, and grasses that also provide aquatic and wildlife habitat. The composition of vegetation will depend on many factors including regional climate, watershed, and topography (USACE 2013, 2-15).

Protecting riparian areas benefits the hydrology of streams by slowing the velocity of runoff, lowering the temperature of runoff, filtering sediments and nutrient loads from runoff, and shading the surface water thereby lowering its temperature (USACE 2013, 2-15 and 2-16).

3.2 Construction-focused LID BMPs

3.2.1 Site fingerprinting

Site fingerprinting is a strategy to minimize site disturbances during construction by defining the smallest construction zone possible to prevent traffic and storage on conservation areas (USACE 2013, 2-25).

Limiting the boundaries of a work zone preserves many of the existing landscape features like trees, flow paths, and uncompacted soils (USACE 2013, 2-25).

During construction, limit the size of the construction zone by planning disturbance areas, material stockpiles, and traffic routes to fall within the development envelope. Protected soil and vegetation areas should be marked clearly, and existing topography and drainage should be preserved (USACE 2013, 2-25).

3.2.2 Minimize soil compaction

Soils have porous spaces that hold air and water. Those spaces allow rainwater to soak into the ground for water storage and infiltration. When soils are compacted, those pockets of air are compressed and cause a reduction in soil function and structure. Soil compaction happens in construction areas when undeveloped areas are cleared and graded, or in storage areas where materials are stockpiled. Soil compaction also occurs with heavy vehicular or pedestrian traffic (USACE 2013, 2-20).

The purpose of minimizing soil compaction is to retain the hydrologic functioning of soils. Soils that allow for infiltration and water storage increase groundwater recharge, reduce runoff, and pollutant removal as well as increasing space for plant roots to grow (USACE 2013, 2-21).

Minimizing soil compaction in construction sites is a straightforward process. Plan site disturbances and construction traffic in the smallest possible area required. Furthermore, site grading and clearing should be minimized to only that which is necessary and no disturbance areas should be clearly defined and marked. If soil compaction does occur, some soil restoration can be implemented through aeration and the addition of compost and other amendments (USACE 2013, 2-21).

3.2.3 Minimize total disturbed area

Minimizing disturbed areas is a site-level planning strategy that limits the amount of land adversely impacted by development and construction activities. Elements of design and construction that affect the disturbed area are the building footprint and orientation, roads and parking lots, and site grading and material storage during construction (USACE 2013, 2-11 and 2-12).

The benefits of minimizing the total disturbed area include protecting land cover and open spaces while limiting soil compaction and changes in the hydrologic functioning of a site (USACE 2013, 2-12).

3.2.4 Cluster development

Clustering development concentrates buildings, lots, and infrastructure on a smaller portion of a larger site to minimize site disturbances. With strategic site planning, clustering development on less permeable soils allows natural drainage patterns to be retained while also avoiding ecologically sensitive areas (USACE 2013, 2-19).

Consolidating development minimizes both the total disturbed area and total impervious area. Another benefit of reducing the size of a developed area include minimizing infrastructural requirements such as the total length of streets, sidewalks, and traditional stormwater systems to service those areas (USACE 2013, 2-19).

3.2.5 Reduce impervious surfaces

Reducing impervious surfaces is accomplished through careful planning to minimize the area of streets, parking lots, driveways, and roof surfaces.

Reducing impervious surfaces also includes disconnecting large, contiguous, developed areas with pockets of perviousness that allow sheetflow to infiltrate the ground surface (USACE 2013, 2-22).

Reducing impervious surfaces has many benefits including reducing stormwater runoff volume and velocity while encouraging infiltration and evapotranspiration. Disconnecting existing impervious areas with pervious parcels also promotes storage and infiltration as well as settling of pollutant loads (USACE 2013, 2-22).

Reductions in impervious surface areas are achieved through strategies that reduce road widths to the legal minimum, cluster development, and design parking lots with more efficient stall arrangements. Additionally, pervious pavements can be integrated into developments to further reduce impervious surfaces. Other opportunities for limiting sheetflow over impervious surfaces includes directing downspouts to pervious vegetated areas (USACE 2013, 2-22 and 2-23).

4 Structural LID BMPs in Historic Districts

Structural BMPs are small-scale, designed controls that allow stormwater to be managed in ways that emphasize or reintroduce the workings of the natural hydrologic cycle (DoD 2015, 27).

Locating and sizing structural LID elements is determined by climatic conditions, land use, calculated runoff volume, soils, and the complexities of the overall existing stormwater management system. Selecting the appropriate LID BMP to accommodate all factors is essential for the successful functioning of the system. In developed areas like historic districts, structural BMPs are associated with, connected to, and located near impervious surfaces such as streets and alleyways, parking lots, driveways, and roofs (USACE 2013, 2-26).

Implementing effective structural LID BMPs requires the collaboration of multiple stakeholders. These stakeholders include CRMs, engineers, landscape architects, and installation planners to ensure the requirements for the selected site are addressed. In historic districts, CRMS should act as the facilitator between all parties.

The following sections outline the most common structural LID BMPs and describe how each aids the hydrologic cycle, how each is constructed, and potential locations where each would contribute most effectively. Following the general description of the BMP are details for integrating that BMP into a historic district by providing siting and material recommendations. In USACE 2013 (2-26 through 2-52), the structural LID BMPs covered are:

- Bioretention
- Vegetated swales
- Vegetated filter strips
- Permeable pavements
- Rainwater harvesting
- Green roofs
- Infiltration practices

Be aware that there are many strategies for sustainable stormwater management. This guide covers the ones that are most common and have the greatest potential for incorporation into historic districts.

4.1 Bioretention overview

Bioretention collects and holds stormwater runoff in flat-bottomed, shallow depressions or basins. The basins are vegetated and designed to filter pollutants as stormwater infiltrates into the soil or underlying drain. Bioretention cells are designed for water infiltration, filtration, or a combination of both in order to use the physical properties of water, soils, and vegetation to reduce or remove pollution from stormwater runoff (USACE 2013, 2-26).

As shown by the numbers overlaid in Figure 1, stormwater flows from an impervious surface through a vegetated filter strip (#2). Runoff is slowed and filtered as it passes through dense, deep-rooted vegetation and mulch (#1). Runoff collects in the bottom of the system where it slowly filters through layers of engineered soils and gravels (#3). Overflow drains allow excess stormwater to flow into an underground pipe for conveyance to other LID BMPs (#6).

Figure 1. Diagram of bioretention outlining the flow of water through the system (www.jcswcd.org).

Bioretention BMPs have wide applicability and can be located in or adjacent to most impervious surfaces such as parking lots, roads, medians, and sidewalks.

Bioretention BMPs treat runoff from three types of small drainage areas:

- **Bioretention cells** = ½ acre to five acres
- **Micro-bioretention** = 10,000 square feet up to ½ acre
- **Rain gardens** = less than 10,000 square feet

4.1.1 Site planning considerations

Bioretention can be used in industrial sites, brownfields, and other areas with known water quality issues. To prevent groundwater contamination from polluted runoff, bioretention in these areas must have an underdrain and a geotextile liner included in the designs (USACE 2013, 5-5 through 5-7).

4.1.2 Design basics

Bioretention design is directed by the ecological factors of the site, including climatic conditions, site soils, geology, and groundwater.

Components of bioretention are: plants, mulch or vegetated groundcover, engineered soils, and a gravel foundation with an underdrain and liner, if needed. Other infrastructure that might be included in a bioretention system includes trash racks, low-flow channels, outlet structures, riprap or gabion aprons, and cleanouts (USACE 2013, 5-8).

4.1.3 Maintenance requirements

Some points to remember for maintenance of bioretention sites:

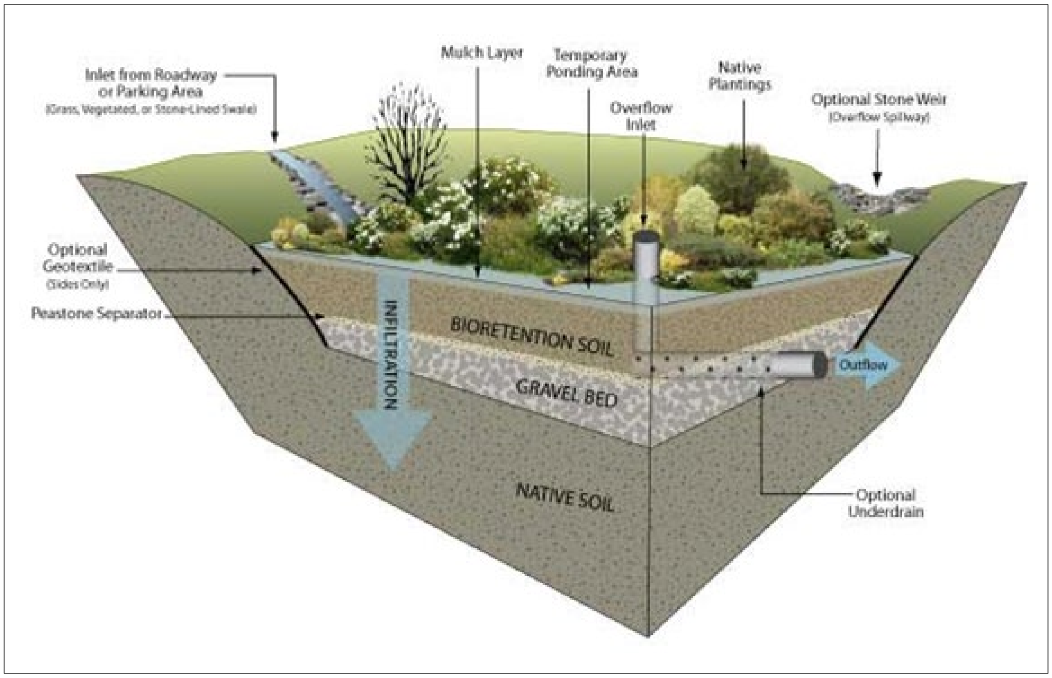
- Perform maintenance when soils are dry to prevent compaction.
- Inspect for clogging and excessive debris and sediment accumulation after all storm events exceeding 1 in. of rain.
- Mow, trim, and prune vegetation on a regular basis (USACE 2013, 5-25).

4.2 Bioretention in historic districts

Bioretention is one of the primary LID BMPs for infiltrating stormwater and has wide applicability throughout a historic district. Because bioretention systems are scaled to treat runoff from three types of drainage areas, they can be located in a variety of spaces that range from several acres to thousands of square feet. As with all structural LID BMPs, all types of bioretention must be located in close proximity to the impervious or pervious drainage areas so that the LID system can collect and treat the runoff (USACE 2013, 2-27).

The main structural components of bioretention lie underground, so a bioretention system can be designed to blend with the landscape characteristics of a historic district through appropriate site selection, vegetation patterns, species selection, and, if used, hardscape materials. While many bioretention systems feature a variety of flowering perennials, the plant selection can be adapted with less ornamental species to fit with the characteristics of administrative or utilitarian land-use areas in a historic district (Figure 2; USACE 2013, 5-22).

Figure 2.Diagram of a bioretention system illustrating less ornamental vegetation selections (www.dceservices.org).



4.2.1 Consulting on bioretention

CRMs should consult with the following subject-matter experts:

- Civil engineers or geotechnical engineers to locate areas for bioretention and to determine if the soils, slope, and site conditions are appropriate for effective functioning.

- Environmental and DPW personnel to determine any environmental impacts of the system.
- A landscape architect or planner to analyze the considered site to determine runoff calculations, planting plans, and maintenance schedules.
- The SHPO and other cultural resources experts to determine if the impacts of the LID system are acceptable.

4.2.2 Historically compatible materials

Bioretention systems have materials that need to be selected carefully for their historic compatibility including vegetation, mulch, stone channels, riprap, concrete, gravel, and overflow inlets. Vegetation must be selected for its performance in the bioretention system, and selections should emphasize native plants with deep root systems that can tolerate wet and dry conditions. Mulches should be natural and in colors that blend with other mulch types in the historic district. Hardscape materials should reflect the color, size, and textures of similar materials approved for use in the historic district.

4.3 Vegetated swales overview

Vegetated swales are broad, shallow channels that direct stormwater surface runoff to a waterbody or stormwater system. Swales are densely planted with grasses, shrubs, and trees to slow and filter stormwater while enabling transpiration and infiltration (USACE 2013, 2-30).

There are three types of vegetated swales: grass, wet, and bioswales (Figure 3). Swales are often used as a pretreatment conveyance system, as an alternative to standard curbs and gutters. Swales are easily modified to increase infiltration rates and overall water quality (ibid.).

Grass swales are similar to conventional drainage ditches, but are designed with flatter slopes for slower water velocity (Figure 3(a). The swale’s length is generally equivalent to the contributing impervious area. Wet swales are similar to grass swales, but intersect the groundwater table and provide stormwater treatment through shallow permanent pools and wetland vegetation (Figure 3(b). Bioswales are similar to bioretention systems, but are used along the edges of contributing impervious areas (Figure 3(c). A bioswale incorporates engineered soils and gravel, and it may have an underdrain system.

Figure 3. Three types of vegetated swales (from left): grass swale, wet swale, and bioswale.

(a) (b) (c)

4.3.1 Site planning considerations

Swales are effective at treating runoff on roadways and along edges of paved areas. All types of swales require a moderate amount of space and must be planned according to the constraints of a site. Swales should be planned for 10-year storms with a maximum ponding time of 48 hours (USACE 2013, 5-32).

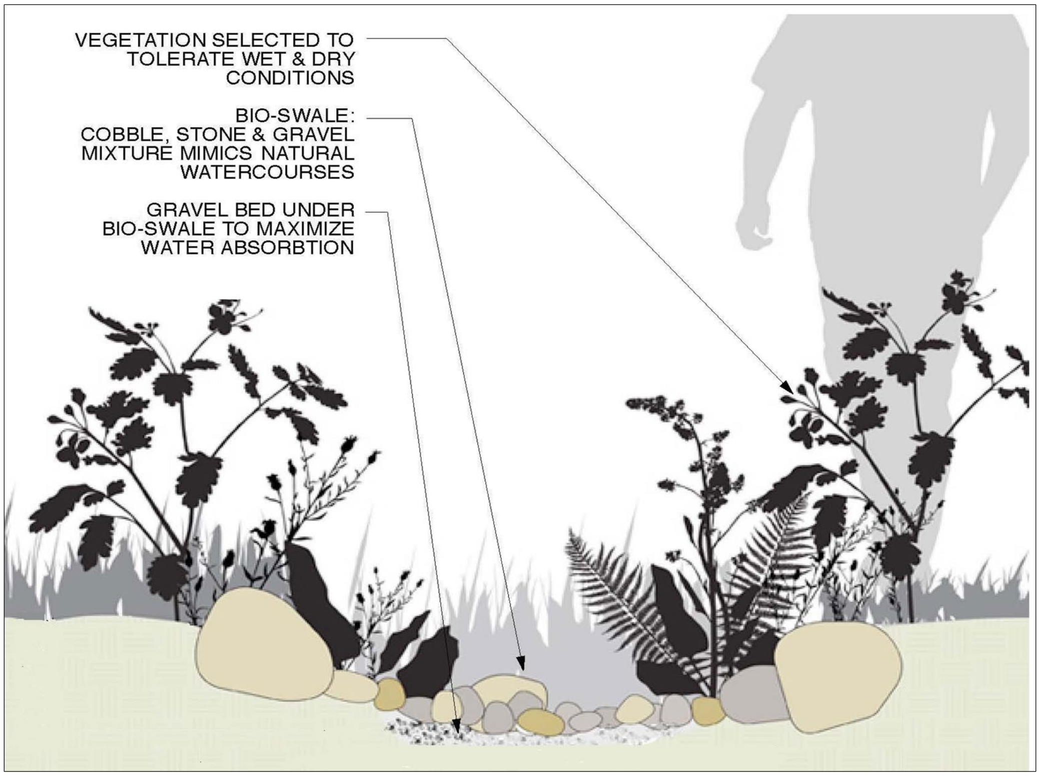
4.3.2 Design basics

Swales are shallow, linear channels with parabolic or trapezoidal cross sections that are designed according to flow rates. All types of swales require gradual slopes to convey water, and the maximum drainage area should never be more than 5 acres. Swales should have dense vegetation that slows water velocity (Figure 4; USACE 2013, 5-32 and 5-33).

The designed components of vegetated swales are:

- pretreatment,
- conveyance and overflow,
- vegetation and planting plan,
- soil media-for bioswales, and
- underdrain and gravel storage layer (for bioswales).

Figure 4.Diagram of a vegetated swale (www.islandhighwayproject.files.wordpress.com).



4.3.1 Maintenance requirements

Vegetated swales have minimal maintenance requirements once the vegetation is established. An annual cleanup with more frequent mowing, pruning, and tree and shrub management should be conducted on a regular basis. Other maintenance may include repairing check dams, stabilizing inlet points, and removing deposited sediment from pretreatment cells (USACE 2013, 5-40 and 5-41).

4.4 Vegetated swales in historic districts

In most historic districts, grass swales are the most historically compatible because of their use of grass and minimal vegetation. With proper planning, grassed swales can be integrated throughout a district with minimal disruption to the district's historic context.

Wet swales and bioswales are more challenging to locate in a historic district because of the increased variety of vegetation used in both of those systems. Nevertheless, wet swales and bioswales can be used in historic districts as long as care is taken to situate swales where their vegetation blends with the surrounding context, for example in a residential area that has more ornamental vegetation, or where dense vegetation will not distract from the historic landscape characteristics (USACE 2013, 5-29 through 5-31).

Swales are located near impervious surfaces, so look for potential sites adjacent to parking lots, roads, and sidewalks (Figure 5).

4.4.1 Consulting on vegetated swales

CRMs should consult with:

- Civil engineers or geotechnical engineers to locate vegetated swales and to determine if the soils, slope, and site conditions allow for vegetated swales.
- Environmental and DPW personnel to determine any environmental impacts of the system.
- A landscape architect to analyze the considered site to determine sizing, runoff calculations, planting plans, and maintenance schedules.
- The SHPO and other cultural resources experts to determine if the impacts of the LID system are acceptable.

4.4.2 Historically compatible materials

Dense vegetation is the primary component of all types of swales. Vegetation should be selected that synthetically blends with a site’s historic planting plans but chosen with an emphasis on using native vegetation. Because vegetation patterns differ throughout a historic district, swales should be located where plantings of grasses, shrubs, and trees will not distract from a district’s historic characteristics.

If hardscape materials are used in a bioswale system, those materials should reflect the color, size, and texture of similar materials throughout the site.

Figure 5. A vegetated swale featuring curb cuts and gravel filtration (waterunderground.files.wordpress.com).

4.5 Vegetated filter strips overview

Vegetated filter strips (VFS) are heavily planted, narrow depressions that collect sheetflow runoff from adjacent impervious areas. Vegetated filter strips can connect to other LID BMPs, vegetated areas, or receiving waterbodies as well as effectively treating runoff from isolated impervious areas such as roofs and parking lots (USACE 2013, 2-33).

A VFS works by slowing runoff velocity and filtering sediments while allowing pollutant uptake. Most often, vegetated filter strips are recommended as pretreatment systems for other LID BMPs (USACE 2013, 2-34).

Runoff through a VFS should remain as sheetflow through the length of the strip and to function most effectively, the runoff must enter the filter strip from above the contributing drainage area. That requirement limits the impervious surface drainage area to 75 ft. Regardless of soils, vegetation, and slope, the minimum filter strip length is 20 ft. Because of their relatively large size requirements and limitations for treating large drainage areas, VFSs are considered a poor stormwater retrofit in urban areas (USACE 2013, 5-42 and 5-43).

4.5.1 Site planning considerations

A VFS needs relatively flat cross slopes and gradual to mild downslopes in order to slow stormwater runoff and remove pollutants. Proper planning for a VFS should consider soils, slope, shape, length, and size of the contributing area, and pollutant loads (USACE 2013, 5-42 and 5-43).

There are several constraints to VFS:

- Runoff has to enter the BMP as sheetflow.
- A VFS is not as effective in high clay soils.
- VFS is not for soils that can’t support a grass cover.
- VFS should not receive “hot spot” runoff.

4.5.2 Design basics

Basic VFS design parameters include establishing the longitudinal slope and length as well as the vegetative cover. Slopes should be 2%–6%. Additionally, the VFS’ slope, length, width, and type of surface cover must respond to site conditions, for the VFS to function effectively (USACE 2013, 5-44).

Vegetation used in a VFS should include grasses and plants having long root systems that provide soil stabilization. Plants should also be able to withstand urban thermal stress, variable soil moistures, drought, and ponding (ibid.).

4.5.3 Maintenance requirements

While vegetated filter strips are being established, they require regular maintenance and inspections. Once established, they only need periodic landscape maintenance. Seeding and replanting should be with plants that have exhibited the ability to thrive in the conditions of the VFS (USACE 2013, 5-50).

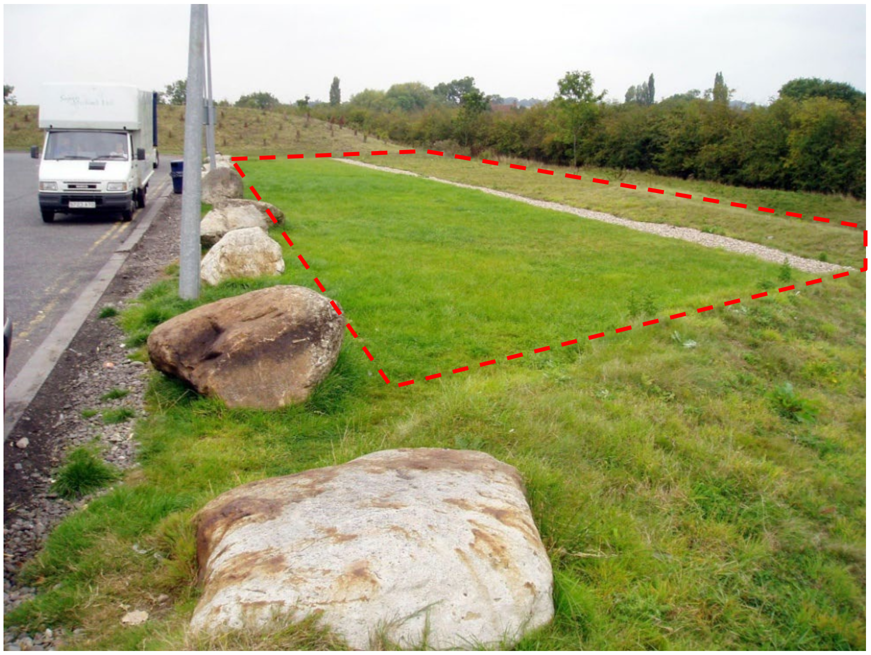
4.6 Vegetated filter strips in historic districts

Because vegetated filter strips can only accommodate sheetflow from relatively small impervious areas and can only treat sheetflow over relatively large areas, finding the appropriate spatial requirements for vegetated filter strip systems in a historic district is potentially challenging. However, if a location has the right spatial requirements, a vegetated filter strip can be integrated easily into the fabric of a historic district using the most basic VFS designs, which are gradual slopes densely planted with turf grass (Figure 6). More elaborately designed VFS can include a gravel trench along the upper gradient edge of the strip for filtering (Figure 7) and dissipating energy as well as permeable berms at the toe of the slope for temporary ponding.

A VFS with more vegetation varieties could be located at the edges of historic districts where a mix of meadow grasses, native perennials, and shrubs would not negatively impact historic landscape characteristics (USACE 2013, 5-49).

Figure 6. A vegetated filter strip along a roadway (www.clemson.edu).

Figure 7. A vegetated filter strip with a gravel diverter (www.susdrain.org).



4.6.1 Consulting on vegetated filter strips

CRMs should consult with:

- Civil engineers or geotechnical engineers to locate vegetated filter strips and to determine if the soils, slope, and site conditions allow for VFS.
- Environmental and DPW personnel to determine any environmental impacts of the system.
- A landscape architect to analyze the considered site to determine run-off calculations, vegetation and planting plans, as well as maintenance schedules.
- The SHPO and other cultural resources experts to determine if the impacts of the LID system are acceptable.

4.6.2 Historically compatible materials

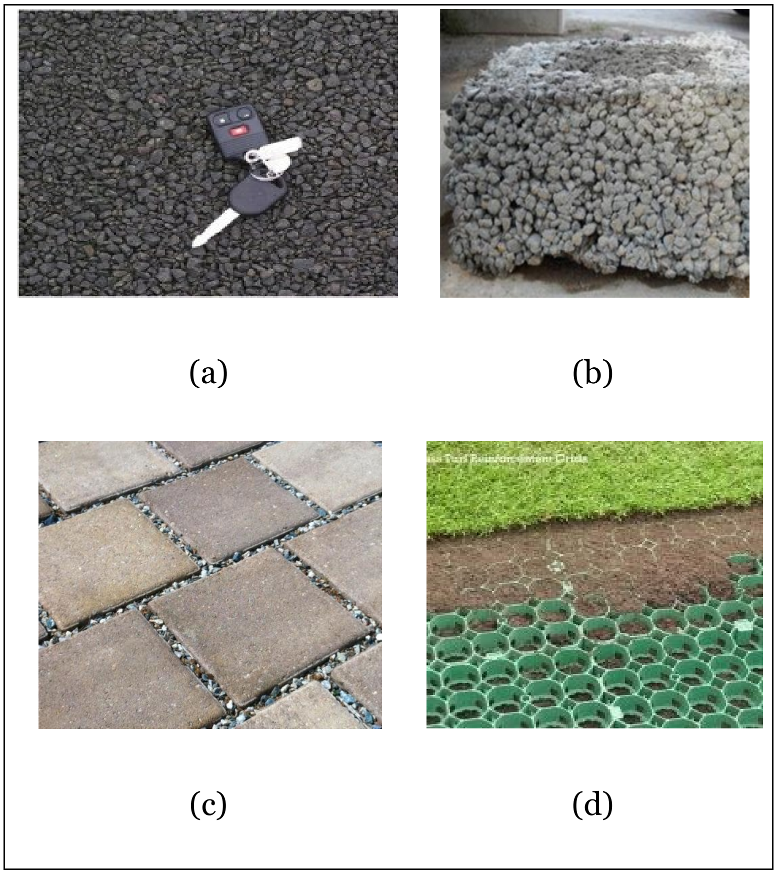
Using turf grass in a VFS is the most historically compatible material for this LID BMP. Nevertheless, options of low-growing grasses, perennials, or shrubs that do not distract from the historic landscape could be used, pending stakeholder approval.

4.7 Permeable pavements overview

Permeable pavements feature porous surfaces that allow water to flow through the paving material into an underlying stone reservoir. The porosity of the paved surface reduces peak flow rates and runoff while the stone bed allows stormwater to be temporarily stored while it gradually soaks into the ground. There are four general types of permeable pavements: porous asphalt, pervious concrete, permeable pavers, and reinforced turf (Figure 8; USACE 2013, 2-37).

Water quality benefits include reducing the volume and velocity of runoff, reducing pollutant and sediment loading, and providing groundwater recharge.

Figure 8. Examples of porous paving; (a) porous asphalt, (b) pervious concrete, (c) permeable pavers, and (d) reinforced turf.



(a) (b)

(c) (d)

4.7.1 Site planning considerations

Permeable pavements can be used in lieu of traditional paving materials, but because of their maintenance requirements they are best suited to areas with light to moderate traffic. Although permeable pavements have a widespread applicability, there are areas where permeable pavements should not be used (USACE 2013, 5-55):

- Sites where excess sediments can be deposited on the pavement surface, for example near steep erosion-prone areas.
- Areas where soils become unstable when saturated.
- Locations where regular maintenance will not be conducted.
- On slopes exceeding 5%.

4.7.2 Design basics

All types of permeable pavements consist of a porous surface, an underlying stone aggregate reservoir layer, and a filter layer or geotextile lining the bottom of the reservoir. An underdrain may be included for heavy rain events (USACE 2013, 5-58).

4.7.3 Maintenance requirements

Permeable pavements need regular maintenance with conventional sweeping, vacuuming, or high-pressure hosing to prevent clogging. Turf pavers and reinforced turf need regular mowing and fertilization, irrigation, and aeration to maintain appropriate grass cover (USACE 2013, 5-62).

4.8 Permeable pavements in historic districts

Permeable pavements have wide applicability throughout historic districts because they can replace existing, or be substituted for, impermeable surface materials (Figure 9). Strategically placed, permeable pavements easily blend into the fabric of most historic districts.

Permeable asphalt and pervious concrete are the most likely materials to be integrated into historic districts, but brick, stone, or concrete pavers have historic precedence. Reinforced turf grids, particularly plastic units, can be used to stabilize historically open, turfed areas to provide additional land-use options while retaining the historic landscape characteristic of open space.

Figure 9. Illustration of low-volume streets and sidewalks retrofitted with permeable pavements (http://iowaenvironmentalfocus.files.wordpress.com/2011/03/charles-city.jpg).

In historic districts, permeable pavements are well-suited for alleyways, parking stalls, driveways, sidewalks, and some recreational surfaces (Figure 10).

The Department of Ecology in the State of Washington has several informative training videos on permeable pavement. The department's website outlines many resources for LIDs for stormwater (Washington 2015).

Figure 10. Permeable concrete (light gray) used throughout a parking lot. (www.dep.wv.gov).

4.8.1 Consulting on permeable pavements

CRMs should consult with:

- Civil engineers or geotechnical engineers to determine if the soils, slope, and site conditions allow for permeable pavements.
- Environmental and DPW personnel to determine any environmental impacts of the system.
- A landscape architect or planner to analyze the traffic patterns of the considered site to determine if the user loads would negatively impact the pavement system. Landscape architects or planners can also develop the maintenance schedule for permeable pavements.
- The SHPO and other cultural resources experts to determine if the impacts of the LID system are acceptable.

4.8.2 Historically compatible materials

Concrete and asphalt are commonly used materials in historic districts. In areas where those materials are used, replacement with permeable variants would likely not cause negative impacts to the historic district.

Nevertheless, pervious concrete does look different than standard concrete, and care should be taken to match colors or to locate pervious concrete in areas where the differences won't significantly impact the historic landscape. Likewise, if pavers are incorporated into the historic landscape they should retain the look, character, texture, and pattern of historic paving systems.

4.9 Rainwater harvesting overview

Rainwater harvesting is a method of collecting and storing rainfall for later use. Systems for harvesting rainwater direct water from rooftops and other impervious surfaces into barrels, tanks, or cisterns. Storage systems can be large or small, depending on volume of runoff and the reuse application for the stored water. The stored water can be used for non-potable applications such as irrigation and in greywater systems (USACE 2013, 2-42).

Collecting rainwater reduces runoff from roofs positively impacting water quality by decreasing peak flows and runoff volumes.

4.9.1 Site planning considerations

Barrels, tanks, and cisterns must be sized for the climate and ranges of annual rainfall for a region. Other factors in sizing include the amount of impervious area that drains into a harvesting system (USACE 2013, 5-66).

Locating rain barrels is straightforward, and they can be retrofitted to existing buildings and easily designed into new structures as long as they are near the areas that will use the stored water. Because they are underground, cisterns require careful planning that takes into account site topography, water table, and soil conditions (Figure 11; ibid.).

Figure 11.. Installation of a large underground cistern system (www.theraincatcherinc.com).

4.9.2 Design basics

Site conditions will influence the design of any rainwater harvesting system. The system should be designed and sized properly to collect as much runoff as possible without depriving downstream uses and water rights. If not all runoff can be captured, an overflow system must be incorporated to discharge water in locations away from building foundations and in areas with erosion controls (USACE 2013, 5-68).

Roofing materials also influence how collected water can be reused with metal and tile roofs providing the highest quality runoff that is generally free from pollutants.

In general, all water collection tanks or cistern systems have the following components (USACE 2013, 69):

- a secure cover
- a screen at the entrance point to keep out leaves and mosquitos
- an inlet filter with cleanout valve
- an overflow pipe
- a manhole, sump, and drain to aid in cleaning

- an infiltration infrastructure that allows spilled water to soak into the ground.

4.9.3 Maintenance requirements

The maintenance requirements for rainwater systems depends on what kind of system is in place and how it is used. Systems used for irrigation have relatively low maintenance requirements while systems designed for indoor water use have much higher requirements (USACE 2013, 5-78).

Both types of systems should be inspected at least twice a year. During these checks debris should be removed, holes repaired, and sediment cleaned from the system.

All tanks must be drained and otherwise winterized to prevent damage from freezing conditions (USACE 2013, 5-78).

4.10 Rainwater harvesting in historic districts

Rainwater harvesting is a viable LID BMP for incorporation into historic districts as long as several basic parameters are established. Water collection systems must be located discretely and cannot compromise the historic fabric of a district. These systems must also be sited where the collected water can be used conveniently and where overflow will not damage surrounding infrastructure.

In most historic districts, smaller-scale systems such as rain barrels can be easily integrated into residential areas by screening them with appropriate vegetation or fencing. In general, most other historic military building types such as administrative buildings, barracks, and utilitarian structures, among others, have roof areas that are too large to have water drained to rain barrels. For these buildings, cistern collection would be most effective. Because they are buried, cisterns have minimal impacts to historic characteristics, but do come with increased planning and construction costs.

Water collection systems must be located in close proximity to where the stored water will be used.

4.10.1 Consulting on rainwater harvesting

CRMs should consult with:

- Civil engineers on the feasibility and impacts of a buried water collection system
- Environmental and DPW personnel to determine any environmental impacts of the system.
- A landscape architect to develop sizing and schematic plan for the collection system and its overflow discharge system.
- The SHPO and other cultural resources experts to determine if the impacts of the LID system are acceptable.

4.10.2 Historically compatible materials

Water collection systems may have been part of the historic military built environment. Nevertheless, modern systems are constructed from different materials and are far more efficient, making them smaller in size and lower in profile (Figure 12). Because of that, modern rainwater collection systems can be incorporated into a historic district as long as care is taken to make them blend with the historic fabric. Buried water collection systems are the most historically compatible as long as the construction does not negatively impact the landscape.

Figure 12. Small-scale, low-profile, above-ground rain collection system (www.tanksalottx.com).

4.11 Green roofs overview

Green roofs consist of a layer of vegetation over all or part of a flat or slightly sloped roof. The roof's vegetation and growing media captures and temporarily stores rainwater, thereby reducing and slowing stormwater discharge from the roof (USACE 2013, 2-44).

Green roof systems are either intensive or extensive. Intensive green roofs have a deep layer of growing media and are more "landscaped" in appearance. Extensive green roofs have a shallow layer of substrate and are limited to low-growing, drought-tolerant plants such as herbs, grasses, mosses, and sedums (USACE 2013, 2-45).

The structural capacity of the building must be considered when designing and planning a green roof.

4.11.1 Site planning considerations

Green roofs are best planned while a building is being designed so that the structural system of the building can be engineered for the extra loads associated with the vegetated system (USACE 2013, 5-82).

On existing buildings, green roofs are most easily installed on flat-roofed buildings that can accommodate the increased loads. Vegetated roofs can be designed for roof slopes of up to 25%, but care must be taken to ensure the roof system will stay in place (USACE 2013, 5-86).

4.11.2 Design basics

There are three primary components in the design of any vegetated roof: drainage, plant nourishment and support, and the underlying waterproofing system (USACE 2013, 5-83).

Green roofs must have a drainage layer that allows excess stormwater to flow through the roof system to an approved discharge location. Designs must be able to accommodate heavy rain events without exhibiting erosion or ponding water (ibid.).

The soil media and plant selection must be designed to meet requirements for porosity ratio, moisture retention, and adequate nutrients for the plants selected. The plants used on green roofs must not need supplemental irrigation or fertilization after the establishment period (ibid.).

Waterproofing systems must be present to prevent leaks that would compromise the building. The waterproofing system must be able to withstand impacts from maintenance and other human uses, and from environmental conditions such as weather events and unintended biological growth (USACE 2013, 5-84).

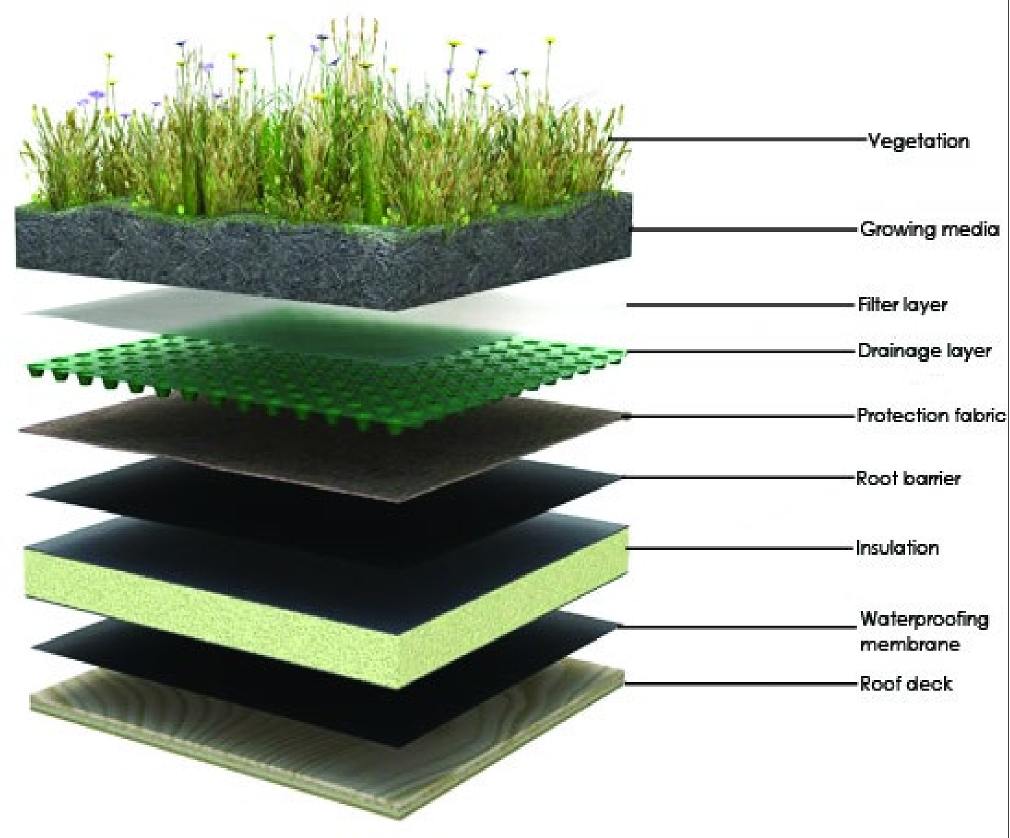
General layers of a green roof are shown in Figure 13.

4.11.3 Maintenance requirements

Generally, there are few maintenance requirements for either type of vegetated roof. However, in the first two years after installation, recommended maintenance for any green roof includes watering, weeding, and fertilizing to establish the vegetation (USACE 2013, 5-90).

After the vegetation is established, green roofs should be inspected twice a year to determine leaks, drainage issues, or structural impacts, and to assess vegetative cover (USACE 2013, 5-91).

Figure 13. General layers in an extensive green roof system (blog.2030palette.org).



http://blog.2030palette.org/wp-content/uploads/2013/08/green-roof-layers.jpg

4.12 Green roofs in historic districts

Although few green roofs were originally constructed on military buildings, green roofs can be integrated into military historic districts as long as they are mostly unseen, or don't distract from the previously identified historic characteristics. Extensive green roofs, with their low-growing vegetation, are the least obtrusive and therefore, the most suitable option for historic district buildings. In most historic districts, extensive green roofs could be integrated into new building designs, but have limited applicability in historic building retrofits due to roof slope, historic roofing materials, and the structural capacity of a building.

In cases where a designated historic building has appropriate roof and structural conditions for a vegetated roof system, other components, such as overflow drains, must be evaluated for potential impacts to the building and the overall historic district characteristics.

Integrating green roofs into historic districts is possible and most feasible on new construction. However, on most historic buildings green roofs are not a viable option due to the many factors required for a successful system.

4.12.1 Consulting on green roofs

CRMs should consult with:

- Structural engineers to determine if an existing building can accommodate the increased loading on the roof.
- Environmental and DPW personnel to determine any environmental impacts of the system.
- A landscape architect, or green roof consultant, to develop a conceptual plan for the green roof design, including overflow to areas around the building. This plan should be analyzed for potential impacts to the historic district.
- The SHPO and other cultural resources experts to determine if the impacts of the LID system are acceptable.

4.12.2 Historically compatible materials

Green roofs can be compatible with historic district design guidelines because they are generally out of sight. Vegetation is the component of a green roof that has the potential to impact the historic district characteristics, therefore, it is essential to select low-growing varieties. Other factors for green roof design and vegetation selection are:

- drought-tolerant plants that will cover 90% of the area in two years
- a minimum of 50% coverage with evergreen species
- a maximum of 10% of the roof area in gravel, ballast, or pavers
- plants must be shallow rooted, self-sustaining, and tolerant of direct sunlight, drought, wind, and frost.

For more information on green roof plants see ASTM E2400M-06, "Guide for Selection, Installation and Maintenance of Plants for Green (Vegetated) Roof Systems" (ASTM 2015).

4.13 Infiltration practices overview

Infiltration practices are naturally occurring or constructed landforms that collect and temporarily store stormwater runoff. Infiltration practices are located in permeable soils to allow the volume of runoff to infiltrate into the surrounding soils. In these systems, stormwater is rapidly filtered, transpirated, and infiltrated. Infiltration practices can be applied in most drainage basins and can be modified to meet the needs of the site conditions (USACE 2013, 2-47).

Infiltration practices mitigate potential flooding by rapidly decreasing peak runoff flow rates and volumes. These practices also reduce pollutant and sediment loads in runoff (ibid.).

There are five general types of infiltration infrastructure (Figure 14):

- Dry wells
- Infiltration basins
- Infiltration berms
- Infiltration trenches
- Subsurface infiltration beds

Many of the infiltration practices can be combined with other LID BMPs to create a treatment train: a system where runoff flows through a series of connected LID BMPs to take collective advantage of specific stormwater management benefits.

4.13.1 Site planning considerations

Infiltration practices must be located in areas where the underlying soils allow for infiltration with the water table or bedrock well below the bottom of the system. Infiltration areas also must be located away from buildings so that seepage or overflows do not affect infrastructure. Infiltration system applicability is limited in areas where there is a risk of groundwater contamination (USACE 2013, 2-51).

4.13.2 Design basics

Infiltration areas are designed to capture stormwater and decrease peak runoff flow rates and volume, reduce pollutants, and increase groundwater recharge. Dry wells, infiltration trenches, and subsurface infiltration beds are all comprised of a rock filled reservoir for temporary water storage and infiltration. Infiltration basins and berms use dense vegetation over naturally permeable soils to detain stormwater for infiltration (USACE 2013, 2-49).

4.13.3 Maintenance requirements

The following are key maintenance requirements for infiltration practices:

- Pretreatment BMPs should be used to protect infiltration areas from sediment loads and erosive velocities.
- Avoid compacting the ground in infiltration areas so that the soils can retain their permeability (USACE 2013, 2-51).

Figure 14. Clockwise from top left: diagram of a dry well, infiltration basin, subsurface infiltration bed, infiltration trench, and infiltration berms.

4.14 Infiltration practices in historic districts

Because of their size, infiltration practices potentially have wide applicability throughout historic districts. However, infiltration practices are effective only when soils are permeable and allow for adequate infiltration rates. Therefore, a soil analysis must be conducted to determine if any of the infiltration practices would work on a potential site.

Like other LID BMPs, infiltration practices are located near sources of runoff. Because they are buried, dry wells and subsurface infiltration beds are the most suitable for historic districts, but they are also disruptive to install. Infiltration basins, berms, and trenches are used to treat smaller areas, and they can be minimally ornamented to blend with a site's historic landscape characteristics.

Infiltration basins and berms are generally grassed, with some additional vegetation to provide stabilization. Many open spaces within a historic district have the potential to be regraded to function as infiltration basins. Infiltration trenches are small drainage areas filled with stones; when appropriately placed, these trenches are small enough to not significantly compromise historic integrity.

4.14.1 Consulting on rainwater harvesting

CRMs should consult with:

- Civil engineers on the feasibility and impacts of any infiltration practices.
- Environmental and DPW personnel to determine any environmental impacts of the system.
- A landscape architect to develop sizing and schematic plans for the system.
- The SHPO and other cultural resources experts to determine if the impacts of the LID system are acceptable.

4.14.2 Historically compatible materials

The primary material used in infiltration basins and berms is turf grass (Figure 15). Ensure that the turf grass used in any infiltration practice is low-growing and does not require frequent mowing.

Stones used in infiltration trenches should be similar in size, color, and texture to other historic landscape elements.

Because dry wells and subsurface infiltration beds are buried, they do not need to be constructed with historically compatible materials. However, care should be taken when backfilling those sites to preserve the historic character of the surface area.

Figure 15. An infiltration basin with moderate vegetation (www.permatill.com).

5 LID Preplanning for Cultural Resource Managers

A critical component for designing effective LID BMPs is their proper siting within the landscape. There are many factors to consider in determining if an LID BMP would function well in a particular site. In historic districts, considerations include soil composition, frequency and volume of rain events, and distance to groundwater that must be aligned with the available space for LID infrastructure, planting patterns and requirements, and the visual impact a LID BMP might have on the surrounding historic context (USACE 2013, 1-3).

CRMs need to understand the natural conditions of a historic district to effectively coordinate LID implementation. Included in that understanding is a basic understanding of military land use, planning and site design requirements, historic district design guidelines, and any other LID-related requirements. Often, military facilities have considered LID requirements and have selected preferred LID BMPs for the installation. With this information, CRMs can make informed suggestions for LID placement that meet both NHPA and EISA Section 438 requirements.

Although many guides have been published on the LID site planning process, most focus on sites that are new developments. However, much of the guidance for new developments also can be applied to developed sites such as historic districts. Site planning occurs at several scales, from regional to installation to site level. CRMs interested in implementing LIDs need to focus primarily on installation and site scales in order to determine LID feasibility.

There are seven steps in the LID site planning process. CRMs can follow these steps as a preplanning exercise to understand the historic district in the context of stormwater management and LID requirements (USACE 2013, 3-10).

Step 1: Site inventory
Step 2: Opportunities and constraints
Step 3: Preliminary calculations
Step 4: Nonstructural LID techniques
Step 5: Structural LID techniques (BMPs)
Step 6: Evaluation of LID controls (BMPs)

Step 7: Recalculation for final review

These planning steps are formulated to bring an LID project from concept to approved design. Steps 1 and 2 yield the most information to CRMs who are evaluating a historic district for potential LID.

5.1 Site analysis

5.1.1 Step 1: Site inventory

A site inventory documents in detail what currently is built on a site as well as the natural site features. For CRMs, the site inventory should cover the entire historic district. Features to document include:

- geological conditions
- soils
- hydrology
- topography
- natural resources
- land use/land cover
- facilities infrastructure
- historic characteristics

While collecting current data through field surveys is beneficial, CRMs can collect much of the data through existing maps and drawings of the historic district. For CRMs engaged in the LID planning process, the most important information from a site inventory will be to know: the locations of impervious surfaces, open spaces available for LID construction, general water flow direction, topography, and land use. From this data, CRMs will be able to narrow down potential sites where the installation of LID BMPs will not compromise the historic landscape characteristics (USACE 2013, 3-10).

More information on assessing natural and infrastructural systems is found in UFC 3-201-01. Chapter 3 of the *Army Low Impact Development Technical User Guide* (USACE 2013) also provides detailed explanations of what to look for in each of the feature categories listed above.

5.1.2 Step 2: Opportunities and constraints

Step 2 uses the information collected during the site inventory phase and compiles it to identify areas of opportunity and constraint for developing nonstructural and structural LID BMPs across a site. Areas of opportunity might be preserving riparian buffers, soils that allow for infiltration without the risk of polluting groundwater, retrofits to traditional stormwater infrastructure, replacement of impermeable surfaces, and using natural topography to inform the placement of swales and bioretention. Possible constraints would include areas of impermeable soils, steep or unstable slopes, areas with the potential to contaminate groundwater. CRMs can consult with facilities planners and public works personnel to understand and derive much of this information. Understanding conditions that make potential sites effective locations for LID, helps CRMs actively participate in the planning process (USACE 2013, 3-16).

5.1.3 Step 3: Preliminary calculations

A necessary component of LID planning is calculating runoff volume, rate, and temperature. Properly sizing LID BMPs ensures they will work effectively given the hydrologic conditions of the site. CRMs should be aware of the hydrologic analysis process, but do not necessarily need to perform those calculations. Calculating the hydrologic conditions of the site can be done in consultation with facility engineers, planners, or landscape architects (USACE 2013, 3-17).

5.1.4 Step 4: Nonstructural LID BMPs

With the information collected in the previous planning steps, conceptual designs for nonstructural BMPs can be formed with the goal of preserving the hydrologic functioning of a site. CRMs should identify sensitive environmental or cultural areas as well as areas to preserve. CRMs should understand nonstructural BMPs enough to make suggestions on how to integrate those ideas into the overall historic district landscape plan (USACE 2013, 3-18).

5.1.5 Step 5: Structural LID BMPs

Because historic districts are developed sites, most of the LID planning of CRMs will involve consulting on the selection, location, and design those BMPs. A foundational element in planning for structural LID BMPs is understanding the basics of the traditional stormwater management system. Ideally, LID BMPs collect and treat the majority of stormwater before it enters the traditional stormwater system. To effectively achieve that diversion, a network of structural LID BMPs might need to be implemented across a site. Therefore, understanding localized site conditions and BMP types will aid CRMs in selecting optimal locations and suggesting the most effective BMPs given the site conditions. For example, CRMs could identify an impervious parking lot in a historic district that could be retrofitted to include pervious paving in the parking stalls and the adjacent drainageways could be engineered into bioswales. Engineers and landscape architects will design the LID structures, but CRMs should consult on and evaluate the impacts of their design on the historic district aesthetics (USACE 2013, 3-20).

5.1.6 Step 6: Evaluate LID BMPs

This step involves checking the conceptual designs of nonstructural and structural LID BMP plans. While CRMs will be involved in this phase, it is not a necessary preplanning activity. Nevertheless, this step reevaluates the proposed designs to determine their effectiveness at meeting the requirements of EISA Section 438. The hydrologic analysis conducted during this step could indicate that additional or larger LID BMPs are necessary for a site (USACE 2013, 3-24).

5.1.7 Step 7: Recalculate for final review

This step ensures that LID designs are clear, and that the LID system will be constructed to design specifications for proper functioning and effectiveness. For CRMs who are analyzing a historic district to determine potential areas for and types of LID BMPs, this step is not essential (USACE 2013, 3-24).

Abbreviations and Terms

Term	Meaning
BMP	best management practice
CRM	Cultural Resources Manager
DoD	Department of Defense
DPW	Directorate of Public Works
EPA	Environmental Protection Agency
EISA	Energy Independence and Security Act of 2007
EO	Executive Order
LID	low impact development
NHPA	National Historic Preservation Act
PWTB	Public Works Technical Bulletin
SHPO	State Historic Preservation Officer
USACE	U.S. Army Corps of Engineers
VFS	Vegetated filter strips
WWI	World War I
WWII	World War II

Nonpoint source pollution comes from many diffuse sources and is distributed across a wide area and into the ground by rainfall and snowmelt.

Time-of-concentration is the time required for a water drop to travel from the most hydrologically remote point in a system to the point of collection.

Sheetflow is a hydrologic term describing flow that occurs overland where there are no defined water channels.

References

ASTM International. 2015. “Standard Guide for Selection, Installation, and Maintenance of Plants for Green Roof Systems.” ASTM E2400M-06 (reapproved 2015). Conshohocken, PA: ASTM International.

Dain-Owens, Anne P. and Ellen R. Hartman. 2012. *Implementing Sustainable Water Management Strategies in Historic Districts*. PWTB 200-1-118. Washington, DC: U.S. Army Corps of Engineers. Accessed online at: http://www.wbdg.org/ccb/ARMYCOE/PWTB/pwtb_200_1_118.pdf.

DA. 2013. “Review of Draft Implementing Guidance, Army Stormwater Management Using Low Impact Development.” DAIM-ODC Memo, 6 May. Washington, DC: Department of the Army.

DoD. 2013. *Civil Engineering*. UFC 3-201-01. Washington, DC: U.S. Department of Defense.

_______. 2015. *Unified Facilities Criteria Low Impact Development*. UFC 3-210-10. Washington, DC: U.S. Department of Defense.

Obama, President Barack. 2015. “Planning for Federal Sustainability in the Next Decade. Executive Order 13693. Washington, DC: The White House. https://www.fedcenter.gov/programs/eo13693/

USACE. 2013. *Army Low Impact Development Technical User Guide*. Washington, DC: Office of the Assistant Chief of Staff for Installation Management, U.S. Army Corps of Engineers.

U.S. Congress. 1966. The National Historic Preservation Act of 1966. Public Law 89-665, as amended. Washington, DC: 89th U.S. Congress

U.S. Congress. 2007. “Energy Independence and Security Act of 2007.” Public Law 110-140. Washington, DC: 110th U.S. Congress.

Washington (State of). 2015. “Municipal Stormwater: Low Impact Development (LID) Resources.” Lacey, WA: Headquarters, Department of Ecology, State of Washington. Accessed August 2015: http://www.ecy.wa.gov/programs/wq/stormwater/municipal/LID/Resources.html.

Young, Rumanda, and Patrick Deliman. 2012. “Low Impact Development in Army Construction.” Presented at NDIA Environment, Energy Security & Sustainability (E2S2) Symposium and Exhibition held 21–24 May in New Orleans, LA. Fort Worth, TX: USACE Fort Worth District. Accessible online at: www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA565641.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE (DD-MM-YYYY) September 2019	**2. REPORT TYPE** Final	**3. DATES COVERED (From - To)**

4. TITLE AND SUBTITLE

Finding Space: A Field Guide for Incorporating Low Impact Developments into Military Historic Districts

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

Ellen R. Hartman

5d. PROJECT NUMBER
14-752

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

U.S. Army Engineer Research and Development Center
Construction Engineering Research Laboratory
2902 Newmark Drive
Champaign, IL

8. PERFORMING ORGANIZATION REPORT NUMBER

ERDC/CERL SR-19-4

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Department of Defense
Legacy Resource Management Program
4800 Mark Center Drive, Ste 16G14
Alexandria, VA 22350

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT

The Department of Defense has been tasked by the Energy Independence and Security Act of 2007 and Executive Order 13693, "Planning for Federal Sustainability in the Next Decade," to conserve and protect water re-sources through increased efficiency, reuse, and management. As a result, sustainable stormwater management strategies are being incorporated throughout the military's built environment to manage stormwater in ways that work with natural hydrologic systems. Collectively, those strategies are called Low Impact Development (LID).

Incorporating LID technologies, or LID BMPs, in designated historic districts requires advanced planning, site analysis, compliance with federal regulations, and coordination between diverse stakeholders. This field guide explains the complex interaction between regulatory requirements and the physical environment to assist cultural resource managers in coordinating with all stakeholders to successfully plan and implement sustainable stormwater management systems.

15. SUBJECT TERMS
Low impact development (LID), stormwater management, cultural resources management, historic sites

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
a. REPORT Unclassified	**b. ABSTRACT** Unclassified	**c. THIS PAGE** Unclassified	SAR	56	**19b. TELEPHONE NUMBER (include area code)**

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. 239.18