# Environmental Sustainability

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Sustainability is commonly defined as meeting the needs of the present without compromising the ability of future generations to meet their own needs. A sustainable community is one that addresses the long-term health of the economy, the environment and social equity, thus preserving the ability of future generations to live and flourish. Particularly in a redeveloping environment like Landmark/Van Dorn, it is critical that the City plan to guide growth and change, addressing all of these principles to create a community that is more environmentally responsible, more economically viable and with a quality of life that attracts and retains residents and workers well into the future. This is the challenge and opportunity for the future of the Landmark/Van Dorn Corridor.

# 8.1. Introduction

As it exists today, the development pattern of large blocks, expansive surface parking lots, and dependence on heavily traveled arterial streets for nearly all connections make pedestrian and bicycle travel from residential areas or between shops in the Landmark/Van Dorn area long and unpleasant. The unattractive, auto-oriented environment, and confusing vehicular access to Landmark Mall detracts from the overall character and quality of the planning area. Existing multifamily units have been built as individual enclaves, on terraced land, with a disconnected street network. The planning area lacks public parks and public open space within easy walking distance. Stormwater management is limited.

However, opportunities exist to improve the sustainability of the Landmark/Van Dorn area. Much of the planning area will redevelop in the next 20-30 years, including several large parcels (such as the Landmark Mall and BJ's sites) and many parcels that are less than 10 acres in size. There is an extraordinary opportunity to redevelop these sites in a sustainable and innovative way using current best practices. Recognizing the opportunity to incorporate sustainable planning and design as the Landmark/Van Dorn area redevelops, the Advisory Group supported the following community goal:

- An area-wide, comprehensive approach should be established for environmentally sustainable development, including Leadership in Energy and Environmental Design (LEED) standards, best practices in local and regional stormwater management, reduced impervious areas, enhanced water quality, and protection and restoration of habitat areas and natural features throughout the planning area.

During the community workshops in May 2008, community members discussed their vision for the future of the Landmark/Van Dorn Corridor planning area and many expressed a desire to improve the environment, reduce surface parking lots, connect to existing trails and open spaces, and rebuild the area in a sustainable way. Advisory Group feedback also included:

- Preserve and enhance existing green space, natural areas, and features; including neighborhood-oriented open space and parks.
- Place emphasis on green-building techniques .
- Enhance the street grid.
- Improve transit.
- Facilitate walkability.
- Transform Van Dorn Street into a "Green Boulevard."
- Create small pocket parks.
- Improve stormwater runoff.
- Reduce the "Heat Island Effect."
- Create green connections.
- Promote environmental sustainability.

In an urban context with limited permeable surfaces, environmental sustainability may be achieved through a comprehensive approach to land use, open space, transportation, infrastructure, and recreation planning efforts

that consider both impervious "grey infrastructure" and "green assets"; such as parkland, landscape buffers, and conservation areas. This "green infrastructure" approach integrates innovative technology with green assets to address stormwater management, energy consumption, and air and water quality. This approach uses natural systems to mitigate human impact on the land and ecosystem. A comprehensive green infrastructure approach is required to improve the quality of the natural environment in today's urban communities.

Furthermore, building and planning techniques should encourage the use of both innovative and traditional open space provision (green roofs, rooftop terraces, urban plazas, pocket parks); stormwater management best management practices (BMPs) such as rainwater capture and reuse, bioswales, street trees, permeable pavers; heightened building practices (LEED and Green Building requirements); commitment of public and private resources to improve the condition of local waterways; increased transit use; and accommodations for safe and accessible bicycle and pedestrian circulation.

Because of the strong and direct connection between green infrastructure and environmental sustainability, a Stormwater Master Plan was prepared as part of the Landmark/Van Dorn Corridor planning effort to evaluate the current level of stormwater management, the impact of stormwater on the environment, and to identify opportunities to improve stormwater management through a green infrastructure approach. This chapter of the Plan will conclude with a summary of the findings and recommendations of the Stormwater Master Plan Technical Report.

## 8.2. City Guiding Documents

A number of existing policies guide the City's environmental and sustainability goals and principles.

### 2004-2015 Strategic Plan

The City embraces environmental sustainability and the second goal of the City Council adopted 2004-2015 Strategic Plan envisions an Alexandria "that respects, protects, and enhances the natural environment" and lays the groundwork for many of the sustainability practices now in place across Alexandria. The six objectives of this goal include:

1. Apply greater environmental sensitivity in planning new development and redevelopment and public facilities.
2. Increase the amount of open space, recreation space, and park acreage per resident.
3. Protect and expand the City's overall tree canopy.
4. Improve appearance of gateways, entrances, and corridors.
5. Increase the number of people who travel in the City by mass transit, bicycle, or walking and become less auto-dependent.
6. Improve the quality of air and water in Alexandria.

### Energy Conservation

The City has also signed an agreement to meet or exceed the Kyoto Protocol greenhouse gas reduction targets through the use of local land planning, urban reforestation, public outreach, and other greenhouse gas reduction strategies. The City has committed to reducing the energy used by the City's existing buildings by 3% per square foot per year through the year 2015, for a total 20% reduction from the 2007 baseline.

### Eco-City Alexandria

In June 2008 the City adopted the Eco-City Charter. With regard to stormwater management, the Eco-City Charter has the following goals:

- Use environmentally responsible flood management, stormwater control, and wastewater treatment to protect the public's health and property.
- Promote - through sustainable practices - safe, swimmable, and fishable waterways for its citizens and visitors, and enhance the ecological integrity of its downstream waters, by minimizing stormwater runoff and pollutants draining to the Potomac River and Chesapeake Bay.

## Green Building

A significant amount of new development and redevelopment will occur in the City over the next 20-30 years, with a large portion occurring in the Landmark/Van Dorn area. The development presents opportunities to implement some of the City's key environmental policies and recommendations. As part of the Eco-City Charter, the City has embarked on an Environmental Action Plan that has an overall goal of reducing the carbon footprint through improvements and application of technology in transportation, land use and building construction. Additionally, the City's Department of General Services, which oversees the construction of publicly-funded and city-owned buildings, requires all new buildings to obtain LEED silver certification. The City is developing guidelines for use of Green Building techniques in new building design and construction, geared primarily toward energy and water conservation. These guidelines are expected to be implemented through the City's development review process for larger buildings and through an aggressive and comprehensive education and promotional campaign targeted at builders of smaller buildings.

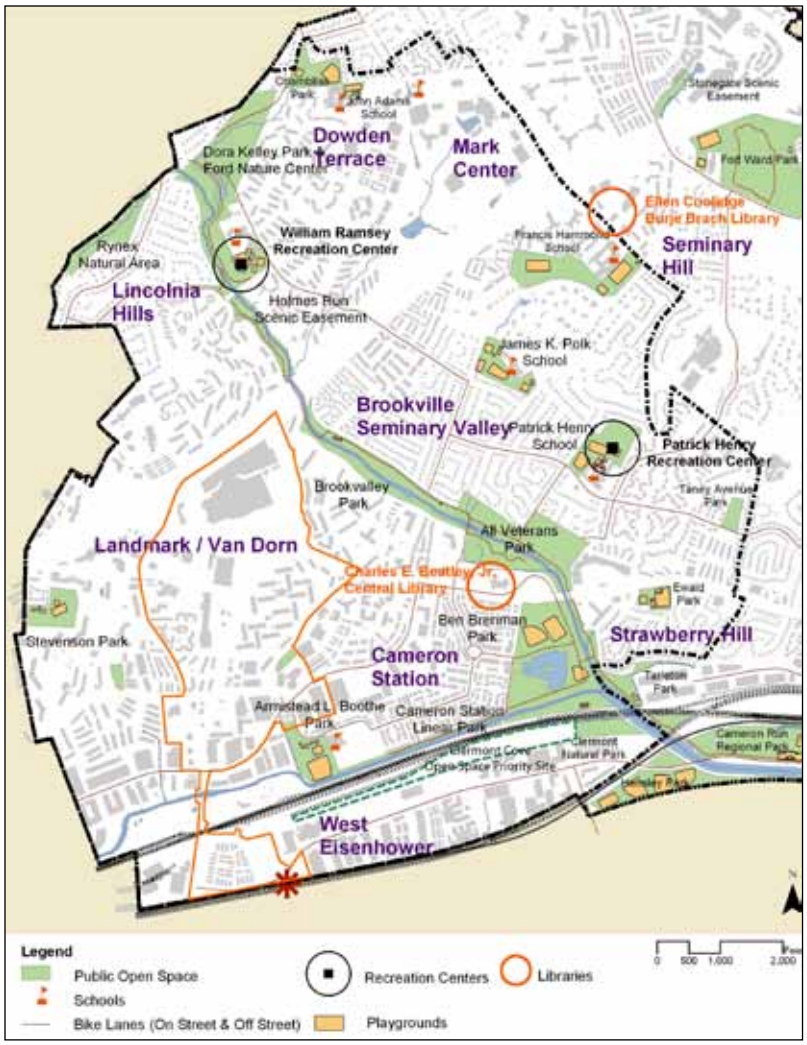



Figure 8-1. Community Facilities and Public Open Space within Context Area

# 8.3. Public Open Space and Trails

## Existing Open Space and Trails

The current zoning regulations require that 40% of the lot area or 400 square feet per dwelling unit for residential uses be reserved as open space, while commercial uses have no open space requirement. In addition to on-site open space required by zoning, the Open Space element of the Master Plan establishes a target of 7.5 acres per 1000 residents for parks and public open space citywide.

Albeit, the planning area lacks public parks and public open space within easy walking distance, there is a network of parks with greenway connections within a mile of most parts of the planning area. Five parks are located near the planning area. These include Brookvalley and Ben Brenman parks which function as community/ urban parks, while the other three are smaller, neighborhood parks. The facilities within the five parks include:

- All Veterans Park (9.6 acres): memorial park, picnic areas, sitting areas, trails for walking, biking, and jogging, and a dog exercise area parallel to Pickett Street.
- Armistead Boothe Park (15 acres): lighted softball / soccer field, a picnic pavilion with grills, restrooms, a playground area with play equipment, two tennis courts, a combination tennis / basketball court, and pedestrian and bike trials.
- Ben Brenman Park (50 acres): softball field, little league baseball field, soccer field, lake with gazebo

Armistead Boothe Park

Holmes Run through Ben Brenman Park

Backlick Run

and fountains, restrooms, pedestrian bridges, picnic pavilion, pedestrian and bike trails, fenced dog park, and a small amphitheater.

- Brookvalley Park (50 acres): community park, scenic natural area, biking and walking, playground, exercise area, sitting and picnic areas, ball field, community garden plots, and the Bicentennial Tree (oldest tree in Alexandria). Brookvalley Park is connected by trail to Holmes Run Scenic Easement to the north, All Veteran's Park to the southwest, and Tarleton Park to the southeast.
- Stevenson Park (9.5 acres): Little League baseball, lacrosse practice and games, soccer practice, basketball court, volleyball, playground, sitting area and park shelter, and summer camp program site.

These parks comprise approximately 134 acres of parkland for 21,240 people residing in the three census tracts that encompass Landmark/Van Dorn. This is approximately 6.3 acres of open space per 1,000 people.

The Holmes Run Trail is part of a regional multi-use trail system that runs along Holmes Run from where it joins Cameron Run into Fairfax County to the west. The Holmes Run Trail connects Ben Brenman, All-Veterans and Brookvalley Parks, which form a continuous open space corridor from Cameron Run to where the trail crosses under I-395.

Ben Brenman and Armistead Boothe Parks are adjacent to Backlick Run. A trail is currently planned along Backlick Run that would connect the Holmes Run Trail at Ben Brenman Park to the trail system on Turkeycock Run just west of Alexandria in Fairfax County.

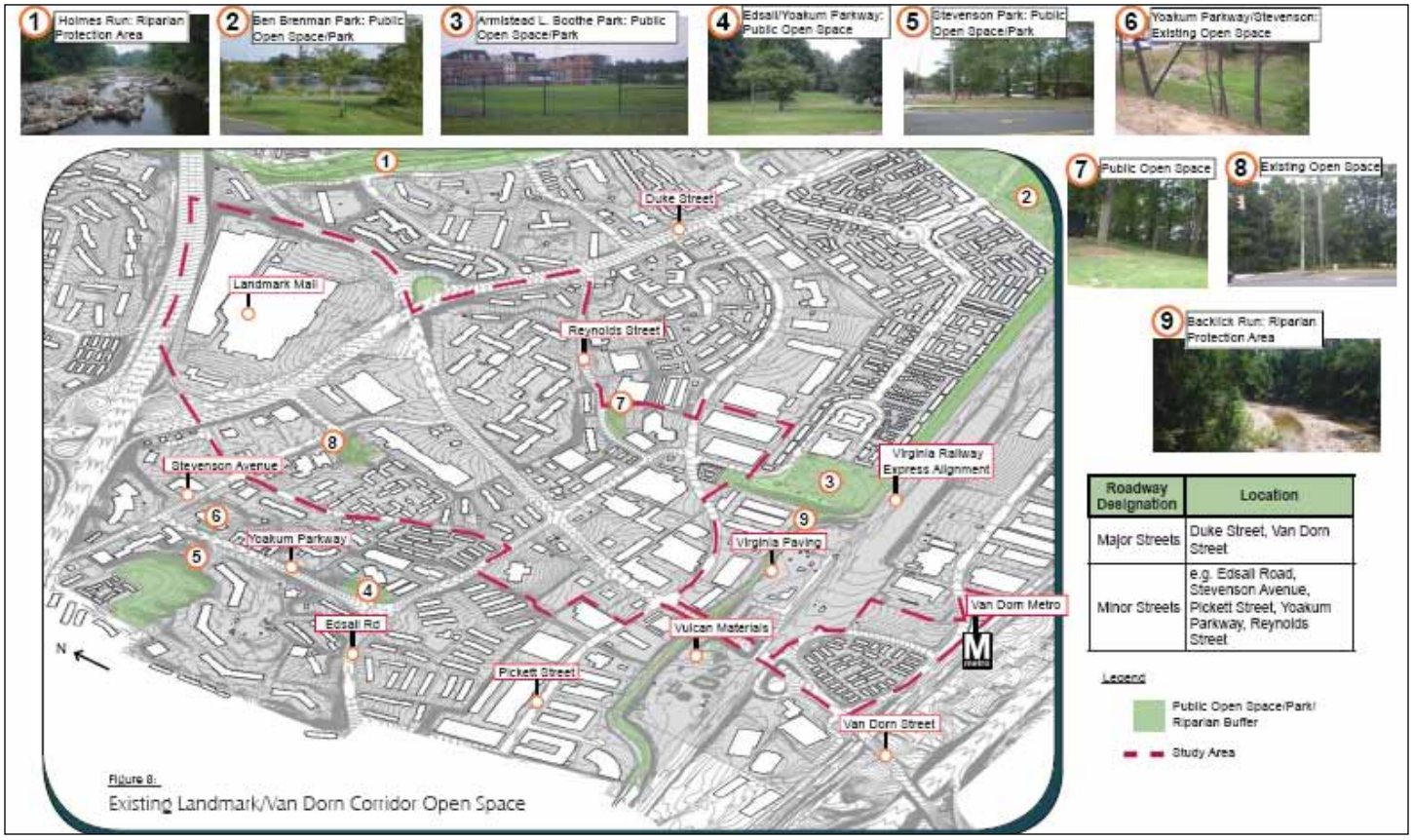



Figure 8-2. Existing open space in the Landmark/Van Dorn area.

# 8.4. Waterways, Stormwater Management, and Green Infrastructure

## 8.4.1. Existing Waterways and Stormwater Management

### Existing Waterways

The planning area is located within the 42-square-mile Cameron Run drainage area. Immediately to the north and south of the planning area boundary are two watercourses, Backlick and Holmes Run. Much of the northern portion of the planning area drains toward Holmes Run; whereas the area generally south of Duke Street drains to Backlick Run. Areas east of the confluence of Backlick and Holmes Run drain directly into Cameron Run. Both are buffered by a 100 ft Resource Protection Area (RPA), which is an environmentally sensitive corridor that should be preserved in its natural condition. Streams demarcated the planning area until the mid 20th century and can be important amenities today. RPAs have many environmental benefits such as flood mitigation, bank stabilization, stormwater retention and treatment, and habitat for local riparian species. Under most circumstances new development is prohibited within the RPA.

### Existing Stormwater Management Conditions

The goal of stormwater management is to mitigate the impact of the continuous movement of water on, above and below the earth's surface due to changes to the land surface. Highly urbanized areas have great impact on the movement of water by reducing or eliminating the natural stormwater infiltration and storage capacity of the land and speeding precipitation from where it lands to receiving waters such as streams and ponds.

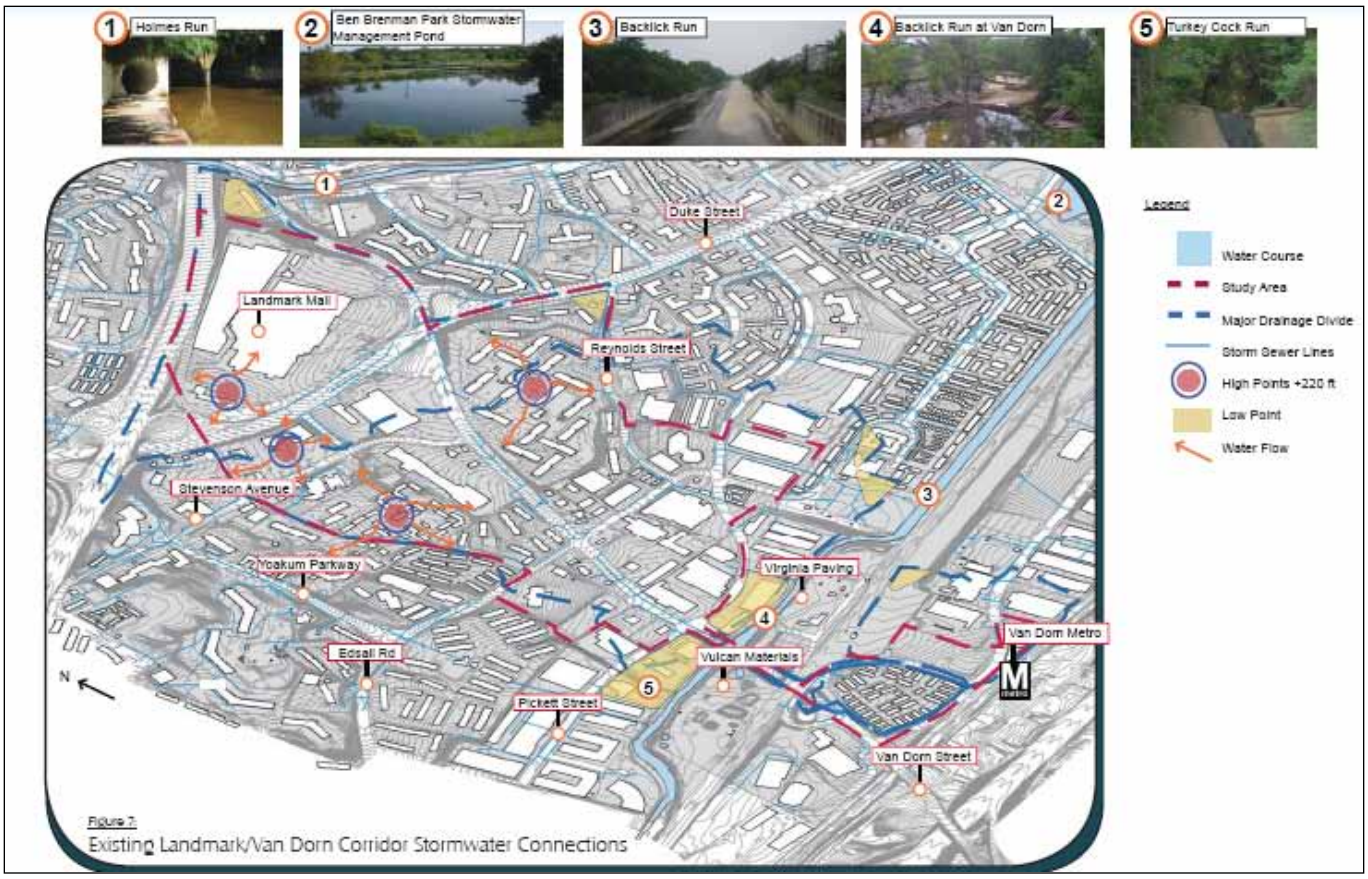



Figure 8-3. Existing stormwater connections in the Landmark/Van Dorn area.

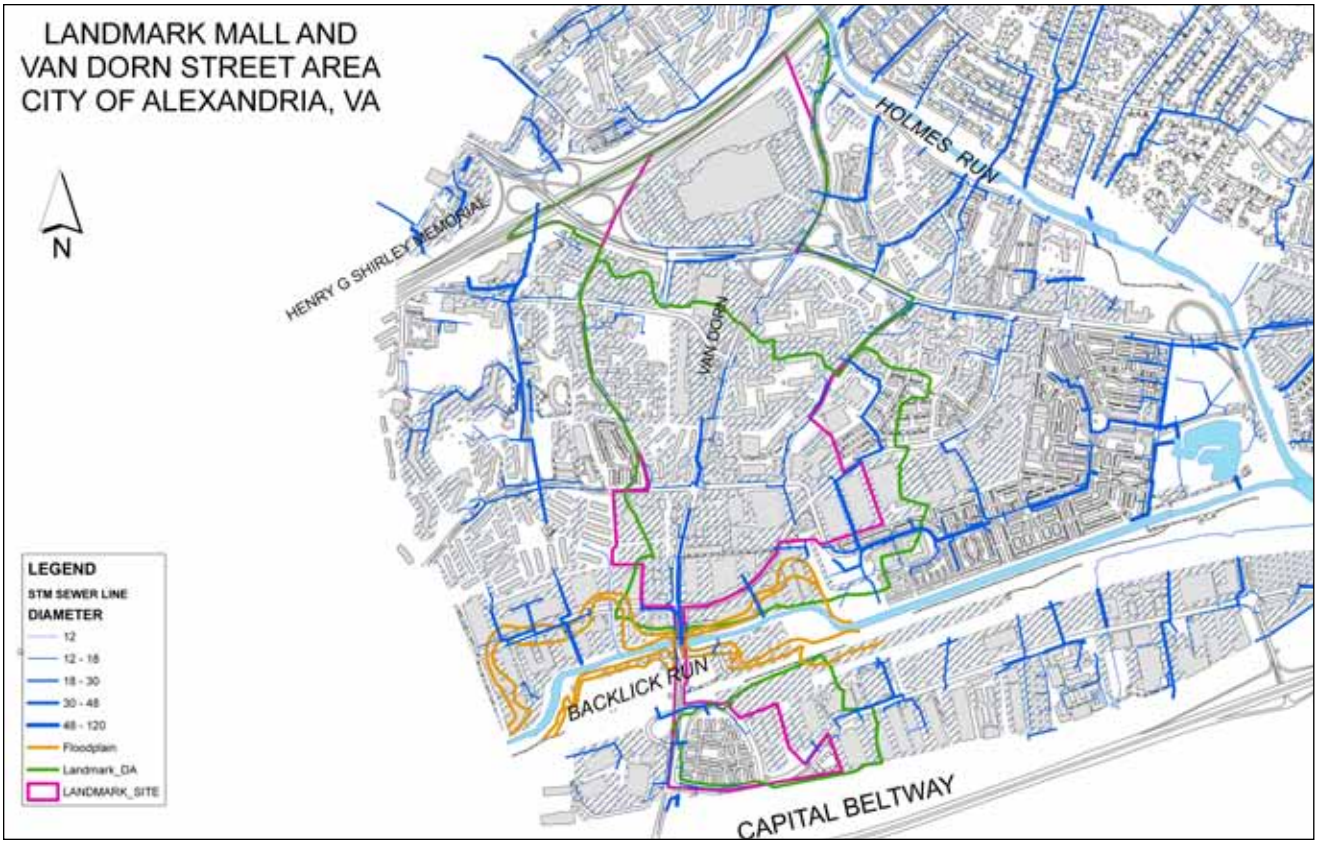



Figure 8-4. Sewer lines in the Landmark/Van Dorn area.

Stormwater in the Landmark/Van Dorn Corridor planning area is mainly managed through an infrastructure system of drainage culverts and storm sewers designed to convey runoff quickly off site. According to the Geographic Information System (GIS) data published by the City in spring 2008, stormwater sewer pipes range from 15 inches to 60 inches in diameter and drain towards the local storm sewer trunk line beneath South Van Dorn Street. The trunk line collects runoff from south of Duke Street and the Van Dorn Street area and discharges to Backlick Run. For the Landmark Mall area, stormwater sewer pipes ranging from 12 inches to 78 inches in diameter drain to the local trunk line beneath Duke Street and discharge into Holmes Run.

The average imperviousness of existing development in the planning area is more than 70%. Development in the planning area occurred primarily before the implementation of stormwater regulations and generally lacks structural stormwater BMPs at individual sites to control the quantity and quality of runoff. In addition, there are no central BMP facilities, such as regional detention ponds, to treat runoff before it is discharged to receiving waters.

Although the planning area makes up only about 1% of the Cameron Run drainage area, the existing stormwater runoff in the planning area has disproportionately high impacts on Backlick and Holmes Run because of the area's high imperviousness and lack of detention or treatment. Such impacts include acceleration of stream velocities and degradation of stream channels, declining water quality, increase in volume of runoff with higher pollutant concentrations, and damage to stream and aquatic life resulting from suspended solids accumulation.

## Existing Stormwater Management Requirements

Stormwater management control measurements can be classified into two categories: stormwater quality control and stormwater quantity control. Many stormwater quality control practices incorporate some stormwater quantity control.

### Stormwater Quality Control

As stormwater travels over land it collects pollutants from diffuse sources, which can then negatively impact aquatic ecosystems. Such pollutants include, but are not limited to, suspended solids, trace metals, fecal contaminants, and hydrocarbons. In addition, summertime stormwater runoff often increases in temperature as it flows over impervious surfaces leading to thermal impacts on receiving water bodies.

The City of Alexandria Article XIII Environmental Management Ordinance sets specific requirements that the entire water quality volume from a redeveloping area be treated. The specific requirements for discharge are defined as follows:

- Post-development pollutant discharge cannot exceed the average City land cover condition of 41 percent imperviousness.

If the existing impervious cover is greater than the 41 percent City average, the following post-development requirements apply:

- If the site is currently served by a stormwater quality BMP, existing pollutant discharge shall not be exceeded
- If the site is not currently served by a stormwater quality BMP, pollutant discharge based on existing conditions shall not exceed the existing discharge minus 10% OR discharge based on the average City land cover condition, whichever is greater.

Stormwater quality requirements apply equally to new development and redevelopment. All new development and redevelopment within the region must reduce the post-development phosphorus load leaving the site in stormwater runoff. Phosphorus is important because it is the leading contributor to eutrophication in the Chesapeake Bay which leads to the reduction of the oxygen content in water. This leads directly to loss of species diversity and water quality.

Backlick Run and Holmes Run, to which the majority of the stormwater from the study area drain, flow directly to Cameron Run. State and local monitoring programs have identified pollutants of concern within the Cameron Run watershed. The US Environmental Protection Agency is required to develop Total Maximum Daily Loads (TMDLs) to reduce pollutant loads that degrade a stream below designated uses. (e.g.; recreation, fishing, boating, etc.). A TMDL is a calculation of the maximum amount of a select pollutant that a water body can receive and still safely meet water quality standards. To ensure compliance with the requirements of the approved TMDL implementation plan, water quality goals for the specified pollutants are incorporated by the State into the local Virginia Pollutant Discharge Elimination System (VPDES) and Municipal Separate Storm Sewer System (MS4) program agreement. An approved TMDL implementation plan requires that Escherichia Coli bacterial loads be reduced in stormwater runoff to Holmes, Backlick and Cameron Runs.

City of Alexandria's Targets of Opportunity Urban Retrofit Program is a public-private partnership which seeks water quality benefits by controlling pollution from previously developed areas of the City. The program seeks opportunities to reduce unnecessary impervious cover, control stormwater runoff, and increase vegetated open space. Where feasible, within groundwater recharge areas such as Landmark/Van Dorn, it specifically applies a metric of reducing existing impervious surface cover by 20 percent during redevelopment and using stormwater infiltration practices where appropriate. Through this program, it is a City objective to reduce non point source pollution by 10 percent.

Other City ordinances, programs, and codes that affect stormwater quality include the Erosion and Sediment Control Ordinance, Flood Overlay Districts (e.g. Backlick Run, Holmes Run and Cameron Run are flood prone areas), and the Virginia Uniform Building Code. The State plans to authorize new stormwater quality legislation by 2010 that is expected to increase the pollutant load restriction even further. Additional pollutants will also be required to be managed in addition to phosphorus.

### Stormwater Quantity Control

Stormwater quantity control manages stormwater runoff volume. Increased peak discharge volumes and quantities increase the likelihood of stream erosion and can cause significant downstream impacts such as flooding. Ideally, control should be implemented so that peak discharge after a site is developed does not exceed peak discharge before development occurred, effectively resulting in no net increase in stormwater quantity.

In accordance with the City of Alexandria Article XIII Environmental Management Ordinance, new development is required to provide site-based stormwater management quantity measures. These state that the post-development peak discharge is not to exceed the pre-development peak discharge for the 2-year and 10-year storm events.

Stormwater quantity control within the City of Alexandria typically applies only to "new" impervious area within a given site. For redevelopment this would mean that stormwater BMPs would ONLY need to manage the quantity of stormwater that runs off from any impervious area at post-development conditions that exceed the impervious area at pre-development conditions. Technically, if a redeveloped site has the same or less total impervious area after development, on-site stormwater quantity measures are not mandatory. As a consequence, the large volume of stormwater runoff that is generated today by impervious areas will continue to degrade receiving waters.

However, new development must also demonstrate that adequate stormwater outfall conveyance exists for each project, even if the peak discharge does not exceed or is less than the pre-development level. If this outfall capacity is not demonstrated, each development will be responsible for providing any needed off-site improvements to provide this adequate outfall capacity

## 8.4.2. Proposals for Stormwater Management and Green Infrastructure

A green infrastructure approach to stormwater runoff issues integrates stormwater management goals with other planning efforts, such as open space, land use, transportation, utilities, and recreational planning. For 30 years, Northern Virginia has implemented various regulations to manage stormwater. The focus has evolved from solely concentrating on flood prevention for large magnitude storm events to addressing water quality, stream channel erosion, and habitat degradation. Small storm events, such as the 1- to 2-year flow events, comprise the majority of the water pollution and erosion damage to nearby streams. By decreasing impervious surfaces and capturing runoff from small storm events on-site, water quality and quantity impacts can be significantly reduced.

To address the issues related to flooding, stream degradation, impaired waterways, and to develop innovative techniques to guide the sustainable redevelopment of the area, the City evaluated existing stormwater management practices and requirements and recommends new strategies, requirements, and BMPs to address stormwater quality and quantity in a sustainable manner. In order to successfully integrate BMP techniques within this green infrastructure strategy, it is desirable that they:

- Have stormwater, aesthetic, and landscape value within the planning area;

- Provide pollutant removal for contaminated stormwater;
- Retain or detain increases in stormwater runoff caused by land use change;
- Offer opportunities for stormwater reuse;
- Link stormwater BMPs to provide stormwater connectivity; and
- Develop an integrated stormwater strategy for both public and private land.

Where appropriate, new policies specific to the planning area are recommended. In some cases, these policies may differ from those contained in the City of Alexandria Stormwater Management Plan and Water Quality Management Supplement, and in those cases, the recommendations herein would apply. A desire for enhanced stormwater requirements and standards for the Landmark/Van Dorn area to exceed existing City of Alexandria and Virginia requirements has provided the opportunity to:

- Control both water quality and quantity beyond the minimum levels required today;
- Guide responsible stormwater management, since redevelopment will not trigger current stormwater quantity regulations if impervious surfaces are not increased;
- Treat the stormwater runoff from the large amount of impervious surface within the study area that is presently not receiving any stormwater quantity or quality treatment;
- Support the City's ongoing efforts to restore Backlick, Holmes and Cameron Runs;
- Reduce flooding through and along these streams;
- Support City initiatives (e.g.: Strategic Plan (2004), Water Quality Management Supplement (2001), Eco-City Charter (2008), Draft Environmental Action Plan (2008/2009), Low Impact Development Design Supplement);
- Recommend a regulatory framework that can facilitate effective stormwater management for the Landmark/Van Dorn area.

## Stormwater Management and Green Infrastructure Recommendations

In order to holistically approach the stormwater management planning effort for the Landmark/Van Dorn Corridor planning area, several stormwater management principles are outlined below. The State is in the process of developing new stormwater management standards. At such time that the standards are promulgated, development and redevelopment shall be subject to the standards shown within this Plan or those of the State, whichever is more stringent.

## Stormwater Management Principles

- Minimize impervious surfaces.
- Provide on-site stormwater management controls as reasonable.
- Consider regional stormwater management controls to collect public and private runoff, if feasible.
- Maximize directing stormwater to landscaped areas.
- Seek opportunities to reuse stormwater.
- Promote rainwater capture and reuse.
- Increase public awareness by exposing stormwater management as an attractive feature in the urban environment.

In addition to the stormwater management principles, several planning area techniques to support stormwater management are provided below.

## Planning Area Techniques

- Consider regional BMPs to control off-site as well as on-site stormwater.
- Provide 30 percent tree canopy coverage within 5 years of occupancy.

Figure 8-5. Cistems For Greywater Re-use, Arlington, VA

Figure 8-6. Bioretention Cells As Part Of Parking Lot Design. Beatley Central Library, Duke Street, City of Alexandria

Figure 8-7. Stormwater Management Pond At Cameron Station. The Pond Located In Ben Brenman Park Collects Runoff From The Cameron Station Development Providing Both Stormwater Management And Aesthetic Benefits

- Provide 25 percent open space on private property.
- Evaluate the feasibility of regional pond facility in the lower drainage area.

The Plan recommends two performance standards to improve water quality and quantity. In order to achieve increased stormwater quality management using a phosphorus load removal performance standard, the Plan recommends the following new standards:

## Performance Standards for Water Quality and Water Quantity

- Capture at least ½-inch of runoff from a site, predominately from impervious surfaces;
- Reduce phosphorus loads by 40 percent.

In order to achieve increased stormwater quantity management by treating all or part of the post development stormwater volume that would exceed average City conditions, The Plan recommends the following standards be applied to all development in the planning area.

For the 1-year, 24-hour storm:

1. Reduce post development runoff to either: match average City conditions (41% imperviousness); OR provide detention for 50% of difference between post development and average City conditions.
2. The runoff hydrograph from the site shall minimize erosion of the receiving stream (Backlick, Holmes, and Cameron Runs).
3. Peak discharge shall not exceed the peak discharge at average City conditions.
4. Credit will be provided for practices that increase open space or employ cisterns for water reuse, green roofs, or other BMPs.

## Best Management Practices

The following BMP techniques listed in Table 8-1 have been selected based upon their appropriateness for integration within the Landmark/Van Dorn Corridor planning area. This list does not represent an exhaustive selection of all BMP techniques currently available, and the possible integration of other BMPs outside of those presented may prove appropriate and should be evaluated on a case by case basis. In addition, it should be noted that the application of several BMP devices in combination with public or private spaces allows for the most effective stormwater management.

The proposed BMPs have been divided into three categories based on site-appropriateness: Category A, Category B, and Category C. Category A includes BMPs that are highly recommended and can be used throughout the planning area. Category B includes BMPs that work best when integrated with open green spaces. Category C includes BMPs that are only appropriate at certain locations in the planning area because site constraints limit their installation widely across the planning area.

### CATEGORY A

Highly Recommended For the Entire Study Area

- Shade Tree Planting
- Street Tree Continuous Root Zone
- Aeration Strip Under Sidewalk
- Soil Amendments
- Bioswales, Bioslopes, Bioretention Cell
- Conservation Landscaping
- Vegetated Filter Strip
- Cisterns – Rainwater Capture and Re-use
- Green Roof

## CATEGORY B

Highly Recommended For Open Space/Green Space Areas

- Conservation
- Reforestation
- Stormwater Management Pond (integrated with open space)

## CATEGORY C

Recommended – Appropriate For Specific Areas Based On

- Porous Pavers
- Permeable Pavements
- Pocket Wetlands
- Stream Daylighting

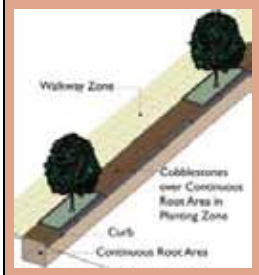
A number of the BMPs listed in Table X (check reference) are composed of vegetative plantings. These vegetative devices require the right mix of natural components, such as soil, mulch, plant species, and micro-organisms. If the devices are constructed correctly they can create wildlife habitats and valuable green spaces for neighborhoods. The natural components include soil characteristics, plant material selection, and plant material placement.

Vegetative BMPs can be an opportunity to create dynamic ecosystems in the urban environment. The current City of Alexandria Landscape Guidelines should serve as the minimum standard. There are a number of design considerations when planning for vegetative BMPs, including:

- Specify native plant materials;
- Create wildlife communities: food, shelter, water, where appropriate;
- Select appropriate vegetation based on the local conditions;
- Identify existing and proposed utilities before placement of plants;
- Do not specify toxic, invasive, or disease prone plant materials; and
- Consider pedestrian traffic and personal safety.

The BMPs recommended herein provide not only stormwater management benefits but contribute to aesthetics, provide open green space, promote innovative building design, support wildlife habitats, decrease “heat island” effect, increase tree canopy, improve air quality, and promote environmental sustainability. All of which, improve the quality of life for residents and visitors of the planning area.

Table 8-1. Best Management Practice (BMP) Techniques Analysis

| BMP TECHNIQUE | DESCRIPTION | KEY MAINTENANCE ISSUES | CHALLENGES |
|---|---|---|---|
| SHADE TREE PLANTING  | Trees provide a first interception of precipitation to help reduce stormwater quantity and heat island effect | • Aeration of soil<br>• Watering<br>• Pruning<br>• Fertilizing<br>• Root penetration to underground utilities | • Space limitations in the urban environment<br>• Plant species selection<br>• Maintenance and oversight<br>• Disease outbreak and conditions of drought<br>• Provide adequate root zone for sustained tree growth |
|   STREET TREE CONTINUOUS ROOT ZONE | Continuous root zones under bricks, pervious pavers or a grid structure topped with a sidewalk help promote healthy street trees allowing for the uninterrupted growth of tree roots. | • Periodic replacement of missing cobblestones<br>• Weeding<br>• Sweeping or vacuuming of sediment between joints | • Not suitable for sidewalks less than 6 feet wide<br>• Plant species selection<br>• Proper installation, maintenance and oversight<br>• Coordination with utilities and other site services |
|  AERATION STRIP UNDER SIDEWALK | Perforated sub-surface strip to extend root growth area. Aeration strips enable trees to safely maximize their root zone. | • None | • Proper installation<br>• Disruption from future utility work or tree replacement<br>• Root penetration into underground utilities |
| SOIL AMENDMENTS   | The addition of any substance to soil that helps to promote plant growth. Examples of amendments include peat, yard compost, and wood chips. | • Mechanical aeration<br>• Organic amendments<br>• Maintain soil stability | • Soil compaction<br>• Excessive root matting |
| BIOSWALES  | Broad shallow vegetated channels that convey and infiltrate stormwater. | • Replacement of dead vegetation<br>• Weeding and removal of invasive plants<br>• Periodic removal of sediment build-up<br>• Trash removal<br>• Underdrain monitoring and flushing | • Plant species selection<br>• Maintenance and oversight<br>• Disease outbreak and conditions of drought |

| BMP TECHNIQUE | DESCRIPTION | KEY MAINTENANCE ISSUES | CHALLENGES |
|---|---|---|---|
| BIOSLOPES  | Bioslopes are slightly compacted vegetative devices that allow stormwater infiltration and prevent erosion from occurring. They can be incorporated in standard slopes or terracing. | • Replacement of dead vegetation<br>• Weeding and removal of invasive plants<br>• Periodic removal of sediment build up<br>• Trash removal | • Plant species selection<br>• Maintenance and oversight<br>• Disease and drought outbreaks<br>• Design for slope stability |
| BIORETENTION CELLS  | Small scale soil and plant based devices located in shallow depressions that promote stormwater infiltration and filtration. | • Replacement of dead vegetation<br>• Weeding and removal of invasive plants<br>• Periodic removal of sediment build up<br>• Trash removal<br>• Underdrain monitoring and flushing | • Plant species selection<br>• Maintenance and oversight<br>• Disease and drought outbreaks<br>• Public awareness<br>• Connection to storm sewers |
|  CONSERVATION LANDSCAPING | A type of landscape that minimizes maintenance and promotes the use of native species to improve air and water quality, create a habitat and enhance species diversity. | • Protection and monitoring to prevent vandalism<br>• Periodic watering during drought<br>• Trash removal<br>• Weeding | • Public awareness<br>• Plant species selection<br>• Maintenance and oversight<br>• Disease and drought outbreaks<br>• Availability of plants |
|  VEGETATED FILTER STRIPS | Dense permanent vegetation with a gentle slope to provide water quality pre-treatment between impervious surfaces and stormwater management devices. | • Replacement of dead vegetation<br>• Weeding and removal of invasive plants<br>• Watering and monitoring<br>• Periodic removal of sediment build up<br>• Trash removal | • Check dams and water energy dissipators may be required to mitigate water velocity<br>• Plant species selection |

| BMP TECHNIQUE | DESCRIPTION | KEY MAINTENANCE ISSUES | CHALLENGES |
|---|---|---|---|
| CISTERNS (GREY WATER REUSE)  | Sub-surface or surface storage tanks designed to accommodate excess stormwater quantity. Water reuse opportunities could include irrigation, toilet flushing or exterior washing e.g. car washing. | • Periodic removal of sediment build up<br>• Periodic inspection<br>• Regular use of harvested water is required | • Construction impacts of large underground systems can be disruptive<br>• Initial costs are high |
| GREEN ROOFS  | Vegetated/planted building roof surface to promote stormwater retention and filtering. | • Replacement of dead vegetation<br>• Weeding and removal of invasive plants<br>• Protection and monitoring to prevent vandalism<br>• Periodic watering | • Roof bearing capacity/ integrity<br>• Adverse impacts from nearby land uses<br>• Maintenance and oversight<br>• Cost |
| CONSERVATION  | Land protected from development and generally preserved as green/vegetated space. Public accessibility may be limited due to location of topographic constraints, however the site may serve as visual greenspace/ landscape buffer to surrounding development. | • Removing diseased trees and vegetation<br>• Controlling invasive plants<br>• Trash removal<br>• Soil amendments as appropriate | • Acquisition of sites<br>• Adverse impacts from nearby land uses<br>• Maintenance and oversight<br>• Disease and drought outbreaks<br>• Compaction and erosion of soils |
| REFORESTATION  | Active (planting) or passive (left with only minor maintenance to allow natural growth) reforestation of open spaces. | • Protection and monitoring<br>• Periodic watering in early years<br>• Trash removal<br>• Controlling invasive plants<br>• Public awareness to prevent mowing of "untidy" greenspaces | • Site evaluation/constraints criteria need to be defined<br>• Plant species selection<br>• Maintenance and oversight<br>• Disease and drought outbreaks<br>• Compaction and erosion of soils<br>• First year establishment |

| BMP TECHNIQUE | DESCRIPTION | KEY MAINTENANCE ISSUES | CHALLENGES |
|---|---|---|---|
| STORMWATER MANAGEMENT POND  | Water body designed and located to store stormwater. | • Replacement of dead vegetation (shoreline and submerged aquatic vegetation)<br>• Control and remove invasive species (plants and animals)<br>• Protection and monitoring to prevent vandalism<br>• Trash removal | • Site evaluation/constraints criteria need to be defined<br>• Safety concerns<br>• Trash removal<br>• Acquisition of sites<br>• Adverse impacts from nearby land uses<br>• Maintenance and oversight<br>• Minimize waterfowl population |
| POROUS PAVERS  Photo: Elizabeth Golden | Pavers installed with voids to allow stormwater to infiltrate and reduce runoff. | • Maintain planting materials away from pavements<br>• Sweeping of debris is required to maintain infiltration rates<br>• Occasional replacement of joint material and weeding<br>• A lower level of winter maintenance is required<br>• Underdrain monitoring and flushing | • Proper installation<br>• Maintain a monitoring system<br>• Periodic and consistent maintenance<br>• Perform snow removal with care |
| PERMEABLE PAVEMENTS   | Poured in place pavement surfaces designed with voids to allow stormwater to infiltrate and reduce runoff. | • Maintain planting materials away from pavements<br>• Vacuuming of debris is required to maintain infiltration rates<br>• Do not use surface sealants<br>• Joint filtering material would need to be replaced occasionally<br>• Underdrain monitoring and flushing<br>• A lower level of winter maintenance is required | • Proper installation<br>• Maintain a monitoring system<br>• Periodic and consistent maintenance<br>• Perform snow removal with care |

| BMP TECHNIQUE | DESCRIPTION | KEY MAINTENANCE ISSUES | CHALLENGES |
|---|---|---|---|
| POCKET WETLANDS  | Small-scale wetlands, often associated with a stormwater pond. | • Replacement of dead vegetation<br>• Weeding and removal of invasive plants<br>• Protection and monitoring to prevent vandalism<br>• Trash removal | • Connection with perennial groundwater<br>• Site evaluation/constraints criteria need to be defined<br>• Public awareness<br>• Safety concerns<br>• Trash removal<br>• Acquisition of sites<br>• Adverse impacts from nearby land uses<br>• Maintenance and oversight |
| STREAM DAYLIGHTING  Photo: Sound Native Plants | Restoring a stream that had been enclosed in a stormsewer pipe, culvert, and/or drainage system to an open and more natural channel. | • Trash Removal<br>• Water quality monitoring<br>• Weeding and removal of invasive plants | • Managing hydrologic conditions<br>• Costly infrastructure improvement<br>• Competing interest for land<br>• Flooding |