Chapter

1.0

Introduction

1.0 Introduction and Purpose of Manual

Title 4, Subtitle 2 of the Environment Article of Annotated Code of Maryland states that "...the management of stormwater runoff is necessary to reduce stream channel erosion, pollution, siltation and sedimentation, and local flooding, all of which have adverse impacts on the water and land resources of Maryland." The program designed in the early 1980s to address this finding of the General Assembly concentrated primarily on controlling runoff increases and mitigating water quality degradation associated with new development. The counties and municipalities in Maryland are responsible for administering effective stormwater management programs that "...maintain after development, as nearly as possible the predevelopment characteristics..." These localities have performed remarkably in establishing Maryland as a national leader in stormwater management technology. Over the last 14 years, tens of thousands of best management practices (BMPs) have been constructed in an attempt to meet program mandates. However, the experience gained since Maryland's stormwater statute was enacted has identified necessary improvements and revealed a need to refocus the approach to fulfill the original intent of this essential water pollution control program.

Recently, increased emphasis on water quality, resource protection needs, increased BMP maintenance costs, and identified shortcomings in Maryland's program have all contributed to basic philosophical changes regarding stormwater management. The "Maryland Stormwater Design Manual" is an effort to incorporate the significant experiences gained by the State's stormwater community and accommodate much needed improvements for managing urban runoff. It is hoped that the design standards and environmental incentives provided below will produce better methods and advance the science of managing stormwater by relying less on single BMPs for all development projects and more on mimicking existing hydrology through total site design policies. Additionally, the inherent philosophical change should produce smaller less obtrusive facilities that are more aesthetic and less burdensome on those responsible for long-term maintenance and performance.

The purpose of this manual is threefold:

❶ to protect the waters of the State from adverse impacts of urban stormwater runoff,

❷ to provide design guidance on the most effective structural and non-structural BMPs for development sites, and

❸ to improve the quality of BMPs that are constructed in the State, specifically with regard to performance, longevity, safety, ease of maintenance, community acceptance and environmental benefit.

The BMPs and the required design criteria below represent conventional stormwater management technology for controlling runoff from new development projects. Based upon current available research, the Maryland Department of the Environment, Water Management

Administration (MDE/WMA) has evaluated each BMP group and the associated design variants and has developed standards for each so that all perform similarly. The "General Performance Standards" outlined in this manual (see Section 1.2, page 1.13) specify those criteria that were used to create runoff control options that would perform equally. The BMPs contained in this manual are by no means exclusive. MDE encourages the development of innovative practices that meet the intent of Maryland's stormwater management law and can perform according to the standards in Section 1.2. In the future, should structural or non-structural practices be developed that meet the standards specified below, MDE will approve their use for controlling new development runoff.

MDE encourages wise, environmentally sensitive site designs to reduce the generation of runoff borne pollution. Additionally, Maryland has adopted "Smart Growth" policies that are geared toward concentrating development where it currently exists thereby reducing "suburban sprawl." Therefore, redevelopment is encouraged. A stormwater management policy for redevelopment is established in the Code of Maryland Regulations (COMAR 26.17.02). Additionally, redevelopment is defined in both COMAR and this manual. While certainly recommended, the BMPs listed below may not be appropriate for redevelopment areas where site size is constrained and existing infrastructure prevents conventional technology. Therefore, redevelopment projects are not required to meet the design standards and performance criteria established in this manual.

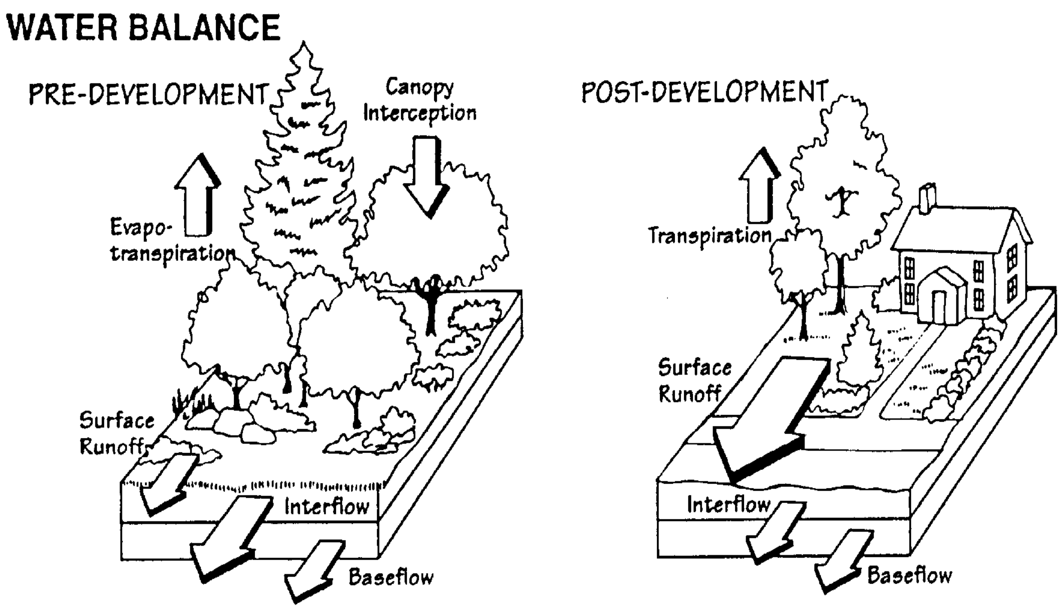
The policy required in COMAR for redevelopment basically specifies a 20% reduction in impervious surface area below existing conditions. Because this may be impractical due to site constraints, MDE is requiring the use of BMPs to meet the equivalent in water quality control of a 20% decrease in impervious surface area. Therefore, various BMPs that do not necessarily meet the performance criteria established in this manual and cannot be used as stand alone stormwater management facilities may be implemented for redevelopment projects. BMPs that cannot be used as stand alone structures may also be implemented to satisfy the pretreatment volume requirements established in Chapter 3 below. Individual project designers should contact the appropriate approval authority for the specific practices allowed for redevelopment and pretreatment purposes.

The approval of new control technologies, modifications to the practices contained in this manual, and alternative policies regarding stormwater management for new development is the responsibility of MDE. Typically, information is submitted to the WMA that describes the policy or practice. For new BMPs, monitoring data need to be submitted that demonstrate that the performance criteria in this manual can be met. WMA then reviews this material to determine if the proposed practice is appropriate for use on new development projects. Because of local variations in ownership policies, maintenance abilities, cost, design standards, hydrology, etc., information on practices to be used for redevelopment and pretreatment should be submitted to the appropriate authority for approval.

Section 1.1 Why Stormwater Matters: Impact of Runoff on Maryland's Watersheds

Urban development has a profound influence on the quality of Maryland's waters. To start, development dramatically alters the local hydrologic cycle (see Figure 1.1). The hydrology of a site changes during the initial clearing and grading that occur during construction. Trees, meadow grasses, and agricultural crops that had intercepted and absorbed rainfall are removed and natural depressions that had temporarily ponded water are graded to a uniform slope. Cleared and graded sites erode, are often severely compacted, and can no longer prevent rainfall from being rapidly converted into stormwater runoff.

Figure 1.1 Water Balance at a Developed and Undeveloped Site
(Source: Schueler, 1987)

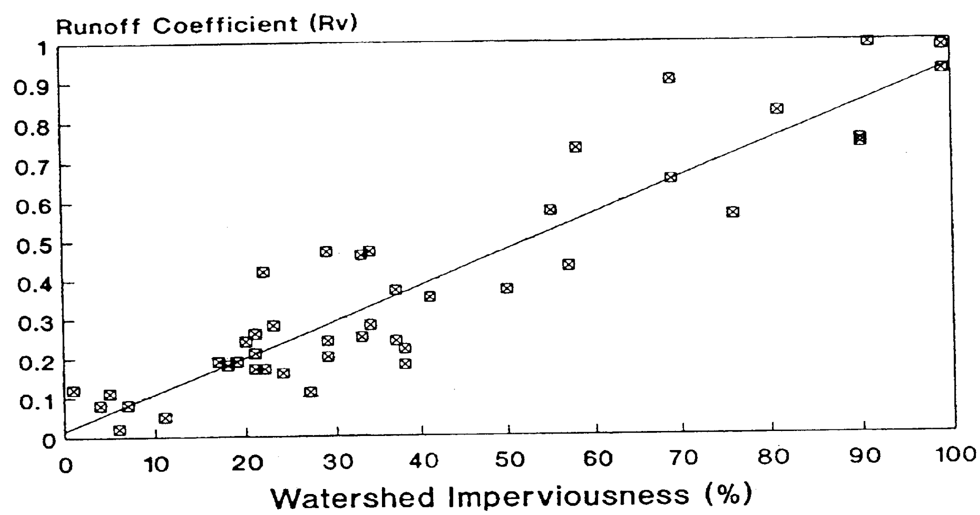


Surface runoff is minimal in an undeveloped site, but dominates the water balance at a highly impervious site.

The situation worsens after construction. Roof tops, roads, parking lots, driveways and other impervious surfaces no longer allow rainfall to soak into the ground. Consequently, most rainfall is converted directly to stormwater runoff. This phenomenon is illustrated in Figure 1.2, which shows the increase in the volumetric runoff coefficient (R_v) as a function of site imperviousness. The runoff coefficient expresses the fraction of rainfall volume that is converted into stormwater runoff. As can be seen, the volume of stormwater runoff increases sharply with impervious cover. For example, a one acre parking lot can produce 16 times more stormwater runoff than a one acre meadow each year (Schueler, 1994).

The increase in stormwater runoff can be too much for the existing natural drainage system to handle. As a result, the natural drainage system is often "improved" to rapidly collect runoff and quickly convey it away (using curb and gutter, enclosed storm sewers, and lined channels). The stormwater runoff is subsequently discharged to downstream waters such as streams, reservoirs, lakes or estuaries.

Figure 1.2 Relationship between Impervious Cover and the Volumetric Runoff Coefficient (Source: Schueler, 1987)



The runoff coefficient (R_v) expresses the fraction of rainfall that is converted into runoff. The data points reflect over 35 monitoring stations in the U.S.

1.1.1 Declining Water Quality

Impervious surfaces accumulate pollutants deposited from the atmosphere, leaked from vehicles, or windblown from adjacent areas. During storm events, these pollutants quickly wash off and are rapidly delivered to downstream waters. Some common pollutants found in urban stormwater runoff are profiled in Table 1.1 and include:

Nutrients. Urban runoff has elevated concentrations of both phosphorus and nitrogen, which can enrich streams, lakes, reservoirs and estuaries (known as eutrophication). In particular, excess nutrients have been documented to be a major factor in the decline of Chesapeake Bay. Excess nutrients promote algal growth that blocks sunlight from reaching underwater grasses and depletes oxygen in bottom waters. Urban runoff has been identified as a key and controllable source. Maryland has committed to reducing tributary nutrient loadings by 40% as part of the Chesapeake Bay restoration effort.

Suspended solids. Sources of sediment include washoff of particles that are deposited on impervious surfaces and the erosion of streambanks and construction sites. Both suspended and deposited sediments can have adverse effects on aquatic life in streams, lakes and estuaries. Sediments also transport other attached pollutants.

Organic Carbon. Organic matter, washed from impervious surfaces during storms, can present a problem in slower moving downstream waters. As organic matter decomposes, it can deplete dissolved oxygen in lakes and tidal waters. Low levels of oxygen in the water can have an adverse impact on aquatic life.

Bacteria. Bacteria levels in stormwater runoff routinely exceed public health standards for water contact recreation. Stormwater runoff can also lead to the closure of adjacent shellfish beds and swimming beaches and may increase the cost of treating drinking water at water supply reservoirs.

Hydrocarbons. Vehicles leak oil and grease that contain a wide array of hydrocarbon compounds, some of which can be toxic at low concentrations to aquatic life.

Trace Metals. Cadmium, copper, lead and zinc are routinely found in stormwater runoff. These metals can be toxic to aquatic life at certain concentrations and can also accumulate in the sediments of streams, lakes and the Chesapeake Bay.

Pesticides. A modest number of currently used and recently banned insecticides and herbicides have been detected in urban streamflow at concentrations that approach or exceed toxicity thresholds for aquatic life.

Chlorides. Salts that are applied to roads and parking lots in the winter months appear in stormwater runoff and meltwater at much higher concentrations than many freshwater organisms can tolerate.

Thermal Impacts. Impervious surfaces may increase temperature in receiving waters, adversely impacting aquatic life that requires cold and cool water conditions (e.g., trout).

Trash and Debris. Considerable quantities of trash and debris are washed through storm drain networks. The trash and debris accumulate in streams and lakes and detract from their natural beauty.

Table 1.1 Typical Pollutant Concentrations Found in Urban Stormwater

Typical Pollutants Found in Stormwater Runoff (Data Source)	Units	Average Concentration (1)
Total Suspended Solids (a)	mg/l	80
Total Phosphorus (b)	mg/l	0.30
Total Nitrogen (a)	mg/l	2.0
Total Organic Carbon (d)	mg/l	12.7
Fecal Coliform Bacteria (c)	MPN/100 ml	3600
E. coli Bacteria (c)	MPN/100 ml	1450
Petroleum Hydrocarbons (d)	mg/l	3.5
Cadmium (e)	ug/l	2
Copper (a)	ug/l	10
Lead (a)	ug/l	18
Zinc (e)	ug/l	140
Chlorides (f) (winter only)	mg/l	230
Insecticides (g)	ug/l	0.1 to 2.0
Herbicides (g)	ug/l	1 to 5.0

(1) these concentrations represent *mean or median* storm concentrations measured at typical sites and may be greater during individual storms. Also note that mean or median runoff concentrations from *stormwater hotspots* are 2 to 10 times higher than those shown here. Units = mg/l = milligrams/liter, µg/l = micrograms/liter, MPN = Most Probable Number.

Data Sources: (a) Schueler (1987) (b) Schueler (1995), (c) Schueler (1997), (d) Rabanal and Grizzard (1996) (e) USEPA (1983) (f) Oberts (1995) (g) Schueler, (1996)

1.1.2 Diminishing Groundwater Recharge and Quality

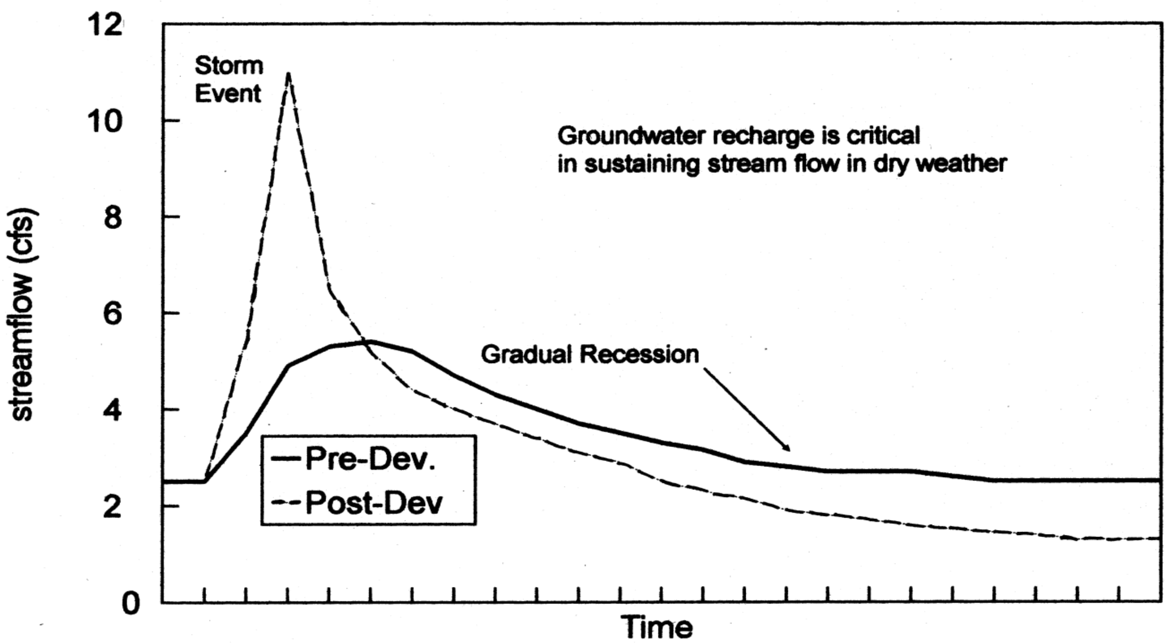
The slow infiltration of rainfall through the soil layer is essential for replenishing groundwater. The amount of rainfall that recharges groundwater varies, depending on the slope, soil, and vegetation. Some indication of the importance of recharge is shown in Table 1.2 which shows Natural Resources Conservation Service (NRCS) regional estimates of average annual recharge volume based on soil type.

Table 1.2 NRCS Estimates of Annual Recharge Rates, Based on Soil Type

Hydrologic Soil Group (NRCS)	**Average Annual Recharge Volume**
“A” Soils	18 inches/year
“B” Soils	12 inches/year
“C” Soils	6 inches/year
“D” Soils	3 inches/year
Average annual rainfall is about 42 inches per year across Maryland.	

Groundwater is a critical water resource across the State. Not only do many residents depend on groundwater for their drinking water, but the health of many aquatic systems is also dependent on its steady discharge. For example, during periods of dry weather, groundwater sustains flows in streams and helps to maintain the hydrology of non-tidal wetlands (Figure 1.3). Because development creates impervious surfaces that prevent natural recharge, a net decrease in groundwater recharge rates can be expected in urban watersheds. Thus, during prolonged periods of dry weather, stream flow sharply diminishes. In smaller headwater streams, the decline in stream flow can cause a perennial stream to become seasonally dry.

Figure 1.3 Decline in Stream Flow Due to Diminished Groundwater Recharge



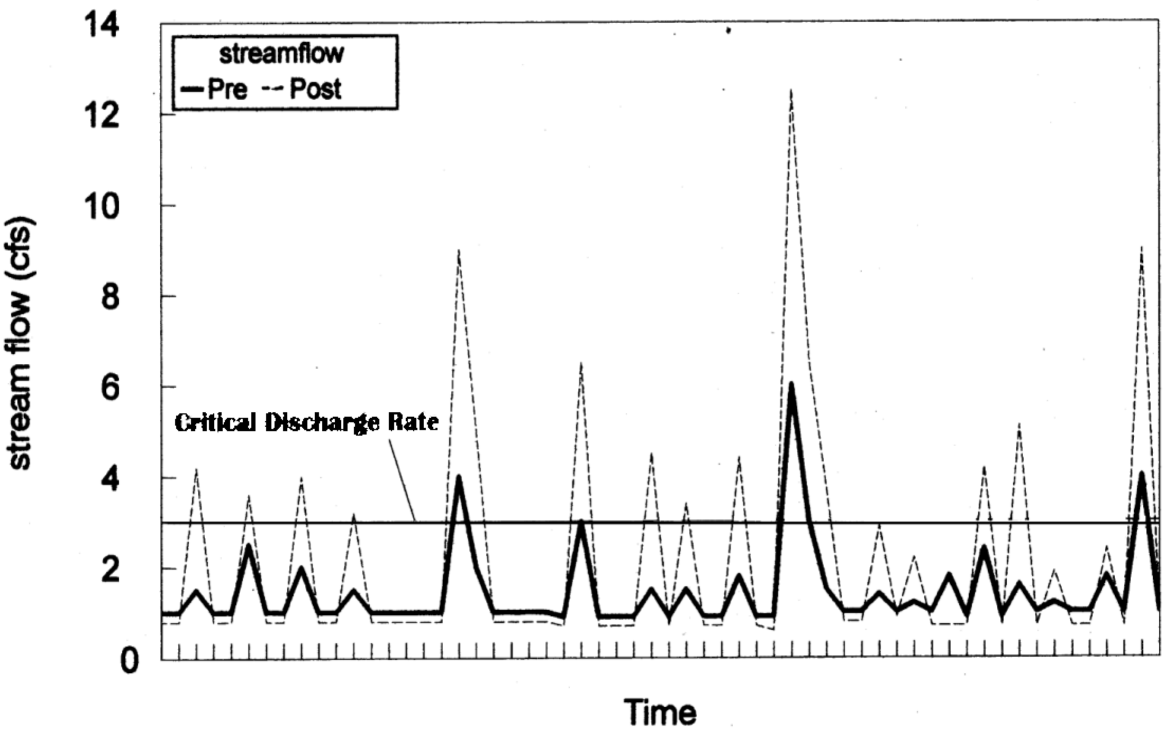
After development, stream flow declines during extended periods of dry weather because of the diminished recharge of groundwater.

Urban land uses and activities can also degrade *groundwater quality* if stormwater runoff is directed into the soil without adequate treatment. Certain land uses and activities are known to produce higher loads of metals and toxic chemicals and are designated as *stormwater hotspots*. Soluble pollutants, such as chloride, nitrate, copper, dissolved solids and some polycyclic aromatic hydrocarbons (PAH's) can migrate into groundwater and potentially contaminate wells. Stormwater runoff should never be infiltrated into the soil if a site is a designated hotspot.

1.1.3 Degradation of Stream Channels

Stormwater runoff is a powerful force that influences the geometry of streams. After development, both the frequency and magnitude of storm flows increase dramatically. Consequently, urban stream channels experience more bankfull and sub-bankfull flow events each year than they had prior to development (see Figure 1.4).

Figure 1.4 Increased Frequency of Flows Greater than the Critical Discharge Rate in a Stream Channel after Development



Development greatly increases the frequency that a stream exceeds the critical discharge rate (the discharge rate associated with bankfull flow) that corresponds to the onset of channel erosion and enlargement.

As a result, the stream bed and banks are exposed to highly erosive flows more frequently and for longer periods. Streams typically respond to this change by increasing cross-sectional area to handle the more frequent and erosive flows either by channel widening or down cutting, or both. This results in a highly unstable phase where the stream experiences severe bank erosion and habitat degradation. In this phase, the stream often experiences some of the following changes:

- rapid stream widening
- increased streambank and channel erosion
- decline in stream substrate quality (through sediment deposition and embedding of the substrate)
- loss of pool/riffle structure in the stream channel
- degradation of stream habitat structure

The decline in the physical habitat of the stream, coupled with lower base flows and higher stormwater pollutant loads, has a severe impact on the aquatic community. Recent research has shown the following changes in stream ecology:

- decline in aquatic insect and freshwater mussel diversity
- decline in fish diversity
- degradation of aquatic habitat

Traditionally, Maryland has attempted to provide some measure of channel protection by imposing the two-year storm peak discharge control requirement, which requires that the discharge from the two-year post development peak rates be reduced to pre development levels. However, recent research and experience indicate that the two-year peak discharge criterion is not capable of protecting downstream channels from erosion. In some cases, controlling the two-year storm may actually accelerate streambank erosion because it exposes the channel to a longer duration of erosive flows than it would have otherwise received.

1.1.4 Increased Overbank Flooding

Flow events that exceed the capacity of the stream channel spill out into adjacent floodplains. These are termed “overbank” floods and can damage property and downstream drainage structures.

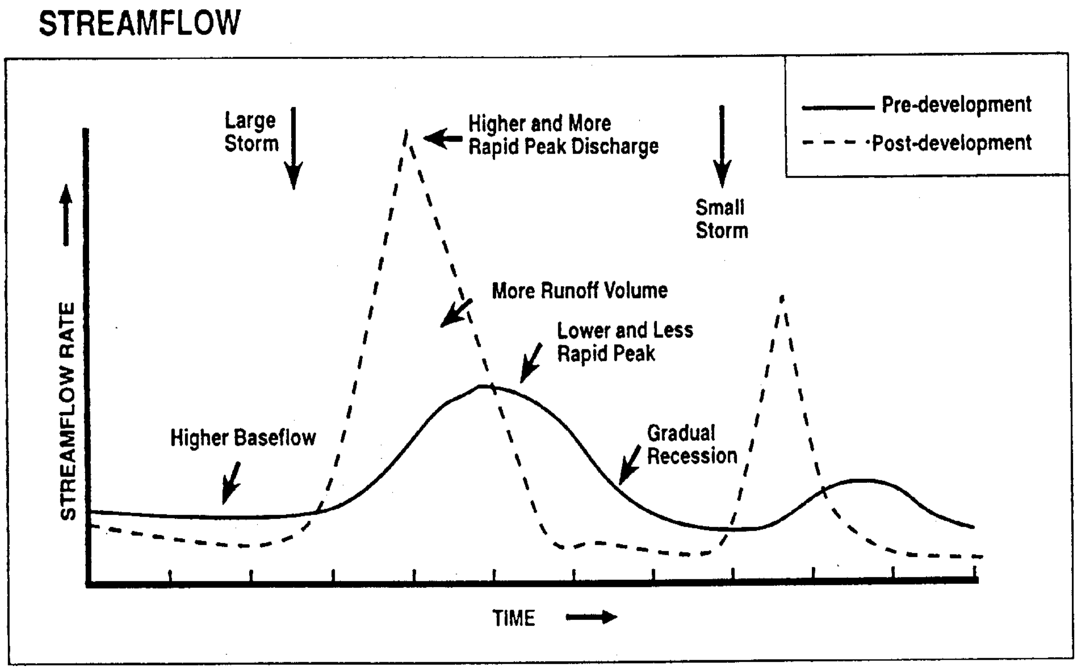
While some overbank flooding is inevitable and even desirable, the historical goal of drainage design in most of Maryland has been to maintain pre development peak discharge rates for both the two and ten-year frequency storms after development, thus keeping the level of overbank flooding the same over time. This prevents costly damage or maintenance for culverts, drainage structures, and swales.

Overbank floods are ranked in terms of their statistical return frequency. For example, a flood that has a 50% chance of occurring in any given year is termed a “two-year” flood. The two-year storm is also known as the “bankfull flood,” as researchers have demonstrated that most natural stream channels in the State have just enough capacity to handle the two-year flood before spilling into the floodplain. In Maryland, about 3.0 to 3.5 inches of rain in a 24-hour period produces a two-year or bankfull flood. This rainfall depth is termed the two-year design storm.

Similarly, a flood that has a 10% chance of occurring in any given year is termed a “ten-year flood." A ten-year flood occurs when a storm event produces about 4.5 to 5.5 inches of rain in a 24 hour period. Under traditional engineering practice, most channels and storm drains in Maryland are designed with enough capacity to safely pass the peak discharge from the ten-year design storm.

Urban development increases the peak discharge rate associated with a given design storm because impervious surfaces generate greater runoff volumes and drainage systems deliver it more rapidly to a stream. The change in post development peak discharge rates that accompany development is profiled in Figure 1.5.

Figure 1.5 Change in Hydrograph following Development
(Source: Schueler, 1987)



The impervious surfaces and conveyance systems of developed sites result in an earlier and higher peak discharge rate.

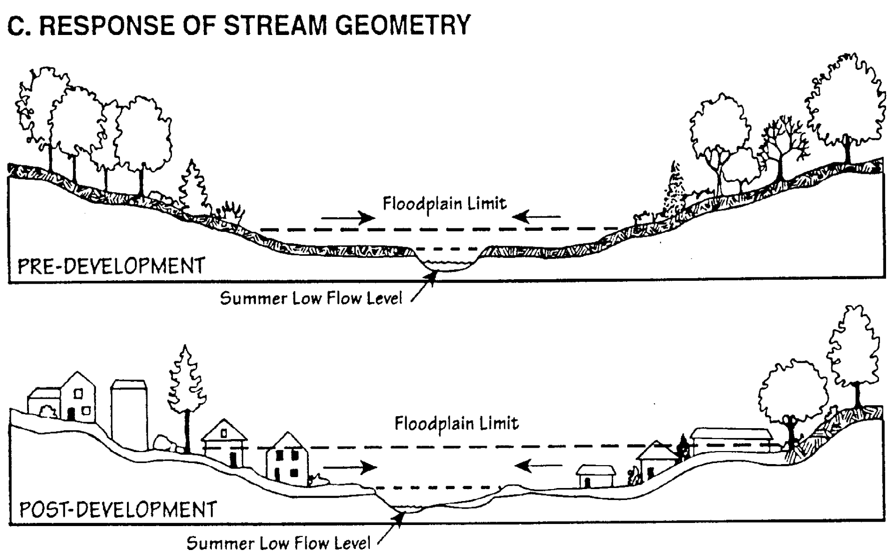
1.1.5 Floodplain Expansion

The level areas bordering streams and rivers are known as floodplains. Operationally, the floodplain is usually defined as the land area within the limits of the 100-year storm flow water elevation. The 100-year storm has a 1% chance of occurring in any given year and typically serves as the basis for controlling development in the State and establishing insurance rates by the Federal Emergency Management Agency. In Maryland, a 100-year flood occurs after about 7 to 8 inches of rainfall in a 24 hour period (e.g., the 100-year storm). These floods can be very destructive and can pose a threat to property and human life. Floodplains are natural flood storage areas and help to attenuate downstream flooding.

Floodplains are very important habitat areas, encompassing riparian forests, wetlands, and wildlife corridors. Consequently, all local jurisdictions in Maryland restrict or even prohibit new development within the 100-year floodplain to prevent flood hazards and conserve habitats. Nevertheless, prior development that has occurred in the floodplain remains subject to periodic flooding during these storms.

As with overbank floods, development sharply increases the peak discharge rate associated with the 100-year design storm. As a consequence, the elevation of a stream's 100 year floodplain becomes higher and the boundaries of its floodplain expand (see Figure 1.6). In some instances, property and structures that had not previously been subject to flooding are now at risk. Additionally, such a shift in a floodplain's hydrology can degrade wetlands and forest habitats.

Figure 1.6 Change in Floodplain Elevations
(Source: Schueler, 1987)



Both the elevation and the lateral boundaries of the 100-year floodplain increase when development occurs upstream.

Section 1.2 General Performance Standards for Stormwater Management in Maryland

To prevent adverse impacts of stormwater runoff, the State of Maryland has developed fourteen performance standards that must be met at development sites. These standards apply to any construction activity disturbing 5,000 or more square feet of earth. The following development activities are exempt from these performance standards in Maryland:

1. Additions or modifications to existing single family structures;
2. Developments that do not disturb more than 5000 square feet of land; or
3. Agricultural land management activities.

The following performance standards shall be addressed at all sites where stormwater management is required:

Standard No. ***1*** *Site designs shall minimize the generation of stormwater and maximize pervious areas for stormwater treatment.*

Standard No. ***2*** *Stormwater runoff generated from development and discharged directly into a jurisdictional wetland or waters of the State of Maryland shall be adequately treated.*

Standard No. ***3*** *Annual groundwater recharge rates shall be maintained by promoting infiltration through the use of structural and non-structural methods. At a minimum, the annual recharge from post development site conditions shall mimic the annual recharge from pre development site conditions.*

Standard No. ***4*** *Water quality management shall be provided through the use of structural and/or non-structural practices.*

Standard No. ***5*** *Structural BMPs used for new development shall be designed to remove 80% of the average annual post development total suspended solids load (TSS) and 40% of the average annual post development total phosphorous load (TP). It is presumed that a BMP complies with this performance standard if it is:*

- *sized to capture the prescribed water quality volume (WQ_v),*
- *designed according to the specific performance criteria outlined in this manual,*
- *constructed properly, and*
- *maintained regularly.*

Standard No. ***6*** *On the Eastern Shore* (see Figure 2.4)*, the post development peak discharge rate shall not exceed the pre development peak discharge rate for the two-year frequency storm event. On the Western Shore, local authorities may require that the post development ten-year peak discharge not exceed the pre development peak discharge if the channel protection storage volume (Cp_v) is provided (see Standard No. 7). In addition, safe conveyance of the 100-year storm event through stormwater management practices shall be provided.*

Standard No. ***7*** *To protect stream channels from degradation, Cp_v shall be provided by 12 to 24 hours of extended detention storage for the one-year storm event. Cp_v shall not be provided on the Eastern Shore unless the appropriate approval authority deems it is necessary on a case by case basis.*

Standard No. ***8*** *Stormwater discharges to critical areas with sensitive resources [e.g., cold water fisheries, shellfish beds, swimming beaches, recharge areas, water supply reservoirs, Chesapeake Bay Critical Area (see Appendix D.4)] may be subject to additional performance criteria or may need to utilize or restrict certain BMPs.*

Standard No. ***9*** *All BMPs shall have an enforceable operation and maintenance agreement to ensure the system functions as designed.*

Standard No. ***10*** *Every BMP shall have an acceptable form of water quality pretreatment.*

Standard No. ***11*** *Redevelopment, defined as any construction, alteration or improvement exceeding five thousand square feet of land disturbance on sites where existing land use is commercial, industrial, institutional or multi-family residential, is governed by special stormwater sizing criteria depending on the amount of increase or decrease in impervious area created by the redevelopment.*

Standard No. ***12*** *Certain industrial sites are required to prepare and implement a stormwater pollution prevention plan and file a notice of intent (NOI) under the provisions of Maryland's Stormwater Industrial National Pollutant Discharge Elimination System (NPDES) general permit (a list of industrial categories subject to the pollution prevention requirement can be found in Appendix D.6). The requirements for preparing and implementing a stormwater pollution prevention plan are described in the general discharge permit available from MDE and guidance can be found in the United States Environmental Protection Agency's (EPA) document entitled, "Storm Water Management for Industrial Activities, Developing Pollution Prevention Plans and Best Management Practices" (1992). The stormwater pollution* *prevention plan requirement applies to both existing and new industrial sites.*

Standard No. ***13*** *Stormwater discharges from land uses or activities with higher potential for pollutant loadings, defined as hotspots in Chapter 2, may require the use of specific structural BMPs and pollution prevention practices. In addition, stormwater from a hotspot land use may not be infiltrated without proper pretreatment.*

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Standard No. ***14*** *In Maryland, local governments are usually responsible for most stormwater management review authority. Therefore, prior to design, applicants should always consult with their local reviewing agency to determine if they are subject to additional stormwater design requirements. In addition, certain earth disturbances may require NPDES construction general permit coverage from MDE (see Appendix D.7).*

Section 1.3 How to Use the Manual

The Maryland Stormwater Design Manual is provided in two volumes. This *first volume* provides designers a general overview on how to size, design, select and locate BMPs at a new development site to comply with State stormwater performance standards. The *second volume* contains appendices with more detailed information on landscaping, BMP construction specifications, step-by-step BMP design examples and other assorted design tools.

Section 1.3.1 VOLUME ONE: STORMWATER MANAGEMENT CRITERIA

The first volume of the manual is organized as follows:

Chapter 1. Introduction to the Manual.

Chapter 2. Unified Stormwater Sizing Criteria. This chapter explains the five new sizing criteria for water quality, recharge, channel protection, overbank flood control, and extreme flood management in the State of Maryland. The chapter also outlines the basis for design calculations. Three step-by-step design examples are provided to familiarize the reader with the new procedures for computing storage volumes under the five sizing criteria. The chapter also briefly outlines the six groups of acceptable BMPs that can be used to meet recharge and water quality volume sizing criteria. Acceptable BMP groups are:

- Stormwater Ponds
- Stormwater Wetlands
- Infiltration Practices
- Filtering Systems
- Open Channel Practices
- Non-structural Practices

Lastly, the chapter presents a list of land uses or site activities that have been designated as "stormwater hotspots." If a development site is considered a "hotspot," it may have special requirements for pollution prevention and groundwater protection.

Chapter 3. Performance Criteria for Urban BMP Design. The third chapter presents specific performance criteria and guidelines for the design of five groups of structural BMPs. The performance criteria for each group of BMPs are based on six factors:

- General Feasibility
- Conveyance
- Pretreatment
- Treatment Geometry
- Landscaping
- Maintenance

In addition, Chapter 3 presents a series of schematic drawings to illustrate typical BMP designs.

Chapter 4. Guide to BMP Selection and Location in the State of Maryland

This chapter presents guidance on how to select the best BMP or group of practices at a new development site, as well as environmental and other factors to consider when actually locating each BMP. The chapter contains six comparative tables that evaluate BMPs from the standpoint of the following factors:

- Watershed Factors
- Terrain Factors
- Stormwater Treatment Suitability
- Physical Feasibility Factors
- Community and Environmental Factors
- Location and Permitting Factors

Chapter 4 is designed so that the reader can use the tables in a step-wise fashion to identify the most appropriate BMP or group of practices to use at a site.

Chapter 5. Stormwater Credits for Innovative Site Planning

Innovative site planning is increasingly recognized as a critical feature of a stormwater plan. This chapter outlines stormwater "credits" that can be obtained when a designer employs progressive planning techniques at the site. The credits not only reduce the impact of development on the environment, but also reduce the size and cost of stormwater practices needed at the site. The six credits include:

- Natural Area Conservation
- Disconnection of Rooftop Runoff
- Disconnection of Non-rooftop Runoff
- Sheet Flow to Buffers
- Open Channel Use
- Environmentally Sensitive Development

The chapter describes how to determine if a site is eligible for credit and how the credit is computed using hypothetical site plan examples.

Section 1.3.2 VOLUME TWO: STORMWATER DESIGN APPENDICES

The second volume is provided separately and contains the technical information needed to actually design, landscape and construct a BMP. Volume Two is divided into four appendices, including:

Appendix A. Landscaping Guidance for Stormwater BMPs. Good landscaping can often be an important factor in the performance and community acceptance of many stormwater BMPs. The Landscaping Guide provides general background on how to determine the appropriate landscaping region and hydrologic zone in Maryland. Appendix A also includes tips on how to establish more functional landscapes within stormwater BMPs and contains an extensive list of trees, shrubs, ground covers, and wetland plants that can be used to develop an effective and diverse planting plan.

Appendix B. BMP Construction Specifications. Good designs only work if careful attention is paid to proper construction techniques and materials. Appendix B contains detailed specifications for constructing infiltration practices, filters, bioretention areas and open channels. In addition, Appendix B includes a copy of the NRCS Code 378 Standards and Specifications for Ponds.

Appendix C. Step-by-Step Design Examples. A series of design examples are provided in this appendix to help designers and plan reviewers better understand the new stormwater sizing criteria and design procedures. Step-by-step design examples are provided for a pond, a sand filter, an infiltration trench, a dry swale, and a bioretention area.

Appendix D. Assorted Design Tools. The last appendix contains an assortment of design tools for stormwater management, including guidance on geotechnical testing, calculating water balance, documenting whether a site complies with the Chesapeake Bay Critical Area "10% Rule," NPDES stormwater permits, pollution prevention, design details, State Water Use Designations and other useful design information.

Section 1.4 Revising the Design Manual

The Maryland Stormwater Design Manual establishes minimum performance criteria that should be met by all techniques and devices used for stormwater management in Maryland. On occasion, variations or other techniques and devices may be found to function better or be more desirable for stormwater management by plan approval authorities. As stated above, MDE is responsible for approving the use of new techniques for controlling runoff from new development. If an approval authority decides it would like to utilize a revised technique or device on a regular basis, it needs to prepare a Standard and accompanying Specifications with a cover letter to be submitted to the MDE/WMA.

A subcommittee consisting of MDE technical personnel will review the revised technique or device and any supporting data submitted. When the technique or device is approved by the technical subcommittee, an approval authorization from the Director of WMA and the technical representative of the local approval authority will be issued. Once the revised or new technique or device has received approval it can be used on a regular basis within the jurisdiction. If other jurisdictions desire to utilize the same technique or device then they must seek approval from the technical subcommittee. A great amount of deviation from the methods within this design manual is not anticipated, but when better stormwater management can be achieved, revisions will generally be looked upon favorably.

Section 1.5 What's New?

This section highlights some of the new stormwater design requirements that are being introduced in the manual. It is provided to help designers understand how the new manual may affect how they prepare stormwater plans and practices. At most sites, designers shall now:

- Measure the amount of impervious cover created by the development.
- Determine if the proposed land use or activity at the site is designated as a "stormwater hotspot."
- Determine the Use Designation of the receiving water and the condition of the watershed.
- Provide a volume that mimics the natural rate of groundwater recharge using structural and/or non-structural BMPs (Re_v).
- Provide storage for extended detention of the one-year, 24 hour storm event to protect downstream channels from erosion (Cp_v).
- Calculate water quality volume using a new methodology (WQ_v).
- Provide water quality volume storage using an approved BMP option that can meet pollutant removal targets.
- Provide extended detention for water quality (ED) in ponds and wetlands as a separate volume. This volume may be calculated apart from the Cp_v.
- Ensure that the BMP selected meets specific performance criteria with respect to feasibility, conveyance, pretreatment, treatment, landscaping and maintenance.

- Follow new geotechnical testing procedures and provide the contractor with formal construction specifications.
- Consider where the BMP is located in relation to natural features and development infrastructure.
- Consider innovative site planning techniques to obtain stormwater credits that can reduce both the size and cost of structural stormwater practices.
- Include operation and maintenance information on approved stormwater management plans.

Section 1.6 Symbols and Acronyms

As an aid to the reader, the following table outlines the symbols and acronyms that are used throughout the text. In addition, a glossary is provided at the end of this volume that defines the terminology used in the text.

Table 1.3 Key Symbols and Acronyms Cited in Manual

A	drainage area	Q_p	overbank flood protection volume
A_f	filter bed area	q_u	unit peak discharge
A_{sf}	surface area, sedimentation basin full	q_p	water quality peak discharge
A_{sp}	surface area, sedimentation basin partial	Re_v	recharge volume
BMP	best management practice	R_v	volumetric runoff coefficient
cfs	cubic feet per second	R/W	right of way
Cp_v	channel protection storage volume (extended detention of the 1-year post development runoff)	S	soil specific recharge factor
CMP	corrugated metal pipe	SD	separation distance
CN	curve number	t_c	time of concentration
d_f	depth of filter bed	t_f	time to drain filter bed
du	dwelling units	TP	total phosphorous
ED	24 hour drawdown of the water quality volume	t_t	time of travel
f	soil infiltration rate	TR-20	Technical Release No. 20 Project Formulation-Hydrology, computer program
fps	feet per second	TR-55	Technical Release No. 55 Urban Unit Hydrology for Small Watersheds
h_f	head above filter bed	TSS	total suspended solids
HSG	hydrologic soil group	V_f	filter bed volume
Ia	initial abstraction	V_r	volume of runoff
I	percent impervious cover	V_s	volume of storage
k	coefficient of permeability	V_t	total volume
P	precipitation depth	V_v	volume of voids
Q_f	extreme flood protection volume	WQ_v	water quality storage volume
q_i	peak inflow discharge	WSE	water surface elevation
q_o	peak outflow discharge		