3 Subwatershed Condition and Plan Action

3.1 Introduction

The following sections provide individual descriptions of the 18 Difficult Run **subwatersheds**, the problems within each of the subwatersheds, the candidate sites that were selected for further investigation and the watershed action, or projects, that are proposed. Topics described for each subwatershed include the following:

- Subwatershed characteristics
- Existing and future land use
- Existing stormwater management
- Outfalls
- Stream crossings
- Soils
- Geomorphology
- Stream habitat and water quality
- Hydrology and water quality modeling
- Hydraulic modeling
- Candidate sites for improvements
- Subwatershed plan actions and recommendations

Mainstem of Difficult Run

The sections below provide background for the content and sources of information that is provided for each subwatershed.

3.1.1 Naming Conventions

Within the County's development of watershed plans, various spatial scales are used for evaluation. Watersheds are divided into subwatersheds, and subwatersheds have been further subdivided into **catchments**. Most analysis has been completed at the subwatershed and catchment levels. Each subwatershed is given a code that identifies its watershed and subwatershed. For example in the Difficult Run watershed (DF), the Captain Hickory Run (CH) subwatershed is coded DFCH. Catchments within the subwatershed are numbered sequentially with a four-digit number. Catchments within Captain Hickory Run are coded DFCH0001, DFCH0002 etc. Additionally, the three subwatersheds along the mainstem have been further subdivided into Difficult Run Lower, Middle and Upper, designated by the addition of L, M or U following the four digit code. Codes for each of the 18 subwatersheds are shown below in Table 3.1.

3.2 Subwatershed Characteristics

The location of each subwatershed and general characteristics are described. Stream lengths and a general stream description are included. Stream lengths are taken from the **geographic information system (GIS)** layers produced as part of the Stream Physical Assessment.

Table 3.1: Subwatershed Codes

Subwatershed	Code	Subwatershed	Code
Angelico Branch	DFAB	Old Courthouse Spring Branch	DFOR
Captain Hickory Run	DFCH	Piney Branch	DFPB
Colvin Run	DFCR	Piney Run	DFPR
Difficult Run, Lower	DFDFL	Rocky Branch	DFRB
Difficult Run, Middle	DFDFM	Rocky Run	DFRR
Difficult Run, Upper	DFDFU	Sharpers Run	DFSP
Dog Run	DFDG	Snakeden Branch	DFSB
The Glade	DFGL	South Fork Run	DFSF
Little Difficult Run	DFLD	Wolftrap Creek	DFWC

3.2.1 Existing and Future Land Use

Analysis of both the existing and future land use is critical to the success of any watershed plan as the land use can have a great impact on the stream system. The type and density of land use in a given area can affect the downstream water quality and stream condition. Each land use type introduces issues to the natural stream system. For example, agricultural land may contribute to higher nutrient **runoff**, while an urban area may contribute greater quantities of stormwater runoff. More intense land use types, such as high-density residential, commercial and industrial, can have high levels of **impervious** surface and contribute runoff and **pollutants** to the stream system. Less intense types such as open space and estate residential are generally less impervious, have more natural vegetation and therefore have less impact on stream quality.

Changes in the land use that result in overall higher intensity uses in the future can result in stream degradation. For example, if the land use shifts from open space to high-intensity commercial use, additional buildings, roadways and parking lots may replace the forest and open fields and impact stream condition through an increase in impervious surfaces. The land use plays an important role in the hydrology and water quality modeling.

The land use data presented in this section is based on the updated GIS land use layer provided by Fairfax County. The 2002 County aerial photography was overlayed with the 1997 land use coded parcel layer. The parcel layer was then updated to match the 2002 photo conditions. In most cases changes we made by recoding the parcel layer. In some instances the actual parcel boundaries were adjusted to match the 2002 data. Future land use was determined through analysis of the Fairfax County future land use GIS data, the County's Comprehensive Plan and Mapping, and the Reston Master Plan. The full land use mapping and imperviousness procedure can be found in Appendix B.

3.2.2 Existing Stormwater Management

Stormwater management provides treatment of otherwise uncontrolled runoff to reduce the harmful effects of increased stormwater flows and stormwater runoff pollution. **Stormwater management facilities** can serve multiple purposes depending on their design. Most facilities constructed prior to 1994 are designed for quantity control only, indicating that they are intended to prevent excessive flows from eroding channels downstream of the facility. Most facilities built after 1994 are designed not only to retain large amounts of stormflow, but also to filter out pollutants that are found in runoff from smaller rainfall events, thereby decreasing the amount of pollutants leaving the facility in an attempt to maintain good water quality downstream of the facility.

Private and public stormwater management facilities are taken from information in Fairfax County's GIS. Information is presented for the percent of area within each subwatershed that receives no stormwater control, that which receives quantity control, and finally, that, which receives both quantity and quality control. Both regional ponds and smaller site-specific ponds are included. Stormwater management facilities are listed in Appendix D. Additionally, the current Master Plan Drainage Projects can be found in Appendix C.

Outfalls

Outfalls, pipes and ditches are the connection between stormwater systems and natural streams and thus are vitally important to the effectiveness of stormwater management and the health of the receiving waters. Field crews collected outfall information as part of the Infrastructure Inventory portion of the Stream Physical Assessment, which was conducted in the fall of 2002 in support of the County's watershed management plans. Outfalls were assessed for erosion and water quality if flowing. In-depth descriptions of the type of data collected by field crews can be found in the Fairfax County Stream Physical Assessment Protocols manual, which includes operating procedures and all field forms. Both qualitative and quantitative descriptions of the data are provided in this report where possible. A brief description of the methods used is provided in the Infrastructure Inventory discussion in Section 3.2.5.

Stream Crossings

Stream crossings are very common in urban and suburban stream systems such as Difficult Run. Crossings are assessed because they are potential locations of erosion, sediment and flooding issues and can present impediments to movement and migration of fish and other aquatic organisms. Field crews collected outfall information as part of the Infrastructure Inventory portion of the Stream Physical Assessment, which was conducted in the fall of 2002 in support of the County's watershed management plans. Crossings were assessed for bed and bank erosion, sedimentation and structural stability. In-depth descriptions of the type of data collected by field crews can be found in the Fairfax County Stream Physical Assessment Protocols manual, which includes operating procedures and all field forms. Both qualitative and quantitative descriptions of the data are provided in this report where possible. A brief description of the methods used is provided in the Infrastructure Inventory discussion in Section 3.2.5.

3.2.3 Soils

Soil erosion and sedimentation play a major role in overall stream health. Erosion is the movement of soil due to wind, rain and related natural forces that carries surface soil toward streams. Although this is a natural process, human activities, such as construction and agriculture, can greatly increase the rate of erosion.

Sedimentation occurs when water carrying the eroded soil particles slows enough to allow the particles to settle out and cover the substrate. Sedimentation can reduce storage volume in reservoirs and stormwater ponds and clog streams. Sediment can affect the physical, chemical and biological water quality and overall ecology of the receiving stream. Smaller particles, such as clays, can stay suspended in the water for very long periods contributing to water **turbidity** or reduced clarity. Chronic suspended solids can also inhibit photosynthetic plant growth. Sedimentation can destroy fish spawning beds, smother benthic invertebrates and submerged aquatic vegetation, destroying essential foods and habitat for fish species. Additionally, sediment can carry organic matter such as animal wastes, nutrients, chemicals and pesticides that may be toxic to aquatic plants and animals.

Soil information is provided for each subwatershed within the Difficult Run watershed. Soil information was obtained from the *Soil Survey of Fairfax County* (NRCS, 1963). Updates to the 1963 survey were added by the Fairfax County Soil Science Office between 1966 and 1990. Those additions were included in the GIS soils data used for the study.

Because there are well over 100 mapped soil types in Fairfax County the number of soils found in each subwatershed is also very high. Therefore, for each subwatershed, the percent coverage of each soil is included only for soils that cover at least 20 acres. Soils are divided for each subwatershed based on their erodibility and drainage properties. Soil erodibility is an estimate of the ability of soils to resist erosion, based on the physical characteristics of each soil type. Generally, soils with higher infiltration rates are less susceptible to erosion. Sand, sandy loam and loam textured soils tend to be less erodible than silt, very fine sand, and certain clay textured soils. Soils on higher slopes (hillside slopes and sloping uplands, for example) are also more susceptible to erosion.

Depth from the soil surface to groundwater is also very important. The closer the water is to the surface, the less chance there is for a pollutant to be filtered and broken down in the soil prior to reaching groundwater and eventually an open stream channel. Information is provided for soils with shallow water tables or shallow depth to bedrock. Information is provided for the hydrologic soil groups.

Soils are classified by the Natural Resource Conservation Service into four Hydrologic Soil Groups based on the soil's runoff potential. The four Hydrologic Soils Groups are A, B, C and D. Where A soils generally have the smallest runoff potential (high infiltration) and Ds the greatest runoff potential (low infiltration).

Group A is sand, loamy sand or sandy loam types of soils. It has low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sands or gravels and have a high rate of water transmission.

Group B is silt loam or loam. It has a moderate infiltration rate when thoroughly wetted and consists chiefly or moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures.

Group C soils are sandy clay loam. They have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine structure.

Group D soils are clay loam, silty clay loam, sandy clay, silty clay or clay. This group has the highest runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface and shallow soils over nearly impervious material. Information on the soil types found within each subwatershed can be found in Appendix A.

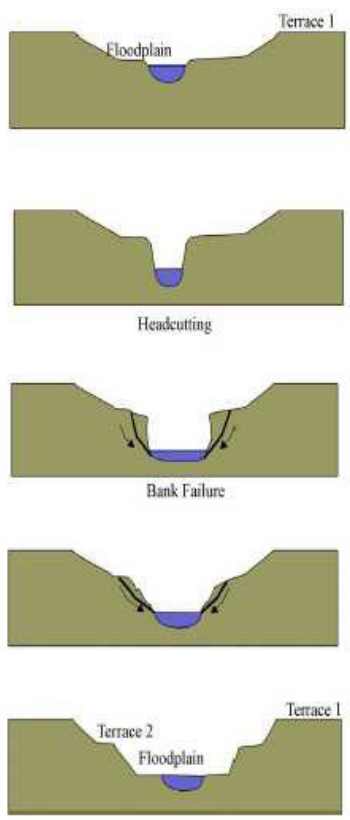
3.2.4 Geomorphology

The assessment of the stream channel **geomorphology** in the Difficult Run watershed is based on the Channel Evolution Model (CEM) by Schumm et al. (1984). The CEM assessment was conducted in the fall of 2002 as part of the Stream Physical Assessment. The model is based on a stream channel's response to anthropogenic activity. Channel types are categorized based on morphological characteristics that are believed to represent an evolutionary stage in a stream channel's response to disturbance. Each assessed stream segment within the Difficult Run watershed was assigned to a category based on visual observation of the channel cross section and other morphological observations. Additionally, cross-section measurements were taken at representative points along the channel. There are five CEM channel types. They are presented in Figure 3.1.

Types II and III are considered the stages that are the most unstable. In Type II, the channel begins adjusting to the higher volumes of flow, higher rates of flow, and more frequent high flows that typically result from changes in land use and increases in impervious surface. The channel first reacts to the higher flows by downcutting in an attempt to increase the channel size. The process continues in Type III channels as the steep banks, that are a result of the downcutting from Stage II, erode and the channel widens.

The downcutting and overwidening of streams is remedied by first controlling the flows through stormwater management techniques and then stabilizing the stream through stream restoration.

Figure 3.1 CEM Types



Type I -- This represents pre-disturbance condition, with well-vegetated streambanks

Type II – This is the first stage after disturbances to the watershed. The dominant physical process in this stage is bed degradation, with the beginning stages of stream incision (downcutting).

Type III – At this stage bed degradation has led to overly steep banks and bank failure is common. This stage is the most unstable of all CEM stages. Channel widening is the dominant physical process in a Type III channel.

Type IV – In Stage IV the dominant physical process is sediment aggradation. This stage is considered the beginning phase of stream stabilization after disturbance.

Type V – Stage V channels are similar to the stream's Stage I channel in dimension and capacity. The new channel is lower than the original channel and the original flood limit is now a terrace.

3.2.5 Stream Habitat and Water Quality

Stream condition information is provided by the Stream Physical Assessment, which included habitat assessments and an inventory of physical habitat problems and infrastructure features.

Habitat Assessment

The Georgia Department of Natural Resources (GADNR) Barbour and Stribling habitat assessment protocol was adopted for the Countywide program with minor modifications. This protocol uses 10 habitat assessment parameters with scores ranging from 0 (worst condition) to 20 (optimal condition). All streams within the Difficult Run watershed are classified as **riffle/run** streams, characterized by high gradient and primarily course sediment substrates. The riffle/run habitat assessment was used. The parameters are presented in Table 3.2 with a brief description. Habitat assessments were conducted throughout the Difficult Run watershed to develop a complete picture of the instream and riparian conditions. The scores from each parameter are combined to produce an overall qualitative narrative rating of Very Poor, Poor, Fair, Good or Excellent.

Table 3.2: Habitat Assessment Parameters

Habitat Parameter	Description of Parameter
Instream Habitat	a measure of the streams suitability for aquatic organisms
Epifaunal Substrate	a measure of the availability of benthic habitat for aquatic macroinvertebrates
Embeddedness	a measure of the amount of fine sediment surrounding substrate rocks
Channel/Bank Alteration	a measure of anthropogenic disturbance
Sediment Deposition	a measure of sediment accumulation and resultant substrate modification
Riffle Frequency	an estimate of the frequency of riffles which are considered a high-quality habitat
Channel Flow Status	a measure of the degree to which the channel bed is covered by water. A decrease in water and subsequent decrease in wetted area reduces the available habitat for aquatic organisms
Bank Vegetative Protection	a measure of the banks ability to resist erosion and uptake nutrients
Bank Stability	a measure of the stream's erosion potential
Vegetative Buffer Zone Width	a measure of the width and condition of the vegetation alongside and within the flood limit of the stream

Infrastructure Inventory

The infrastructure inventory conducted by field crews during the 2002 Stream Physical Assessment includes all structures that may be potential sources of contamination or areas that have the potential for improvement. Information was collected for pipes, ditches, stream obstructions, dump sites, head cuts, utilities, erosion problem areas, stream crossings, and areas of deficient riparian buffer. With the exception of utilities, which are rated on a scale of 20, all infrastructure points are rated on a scale of 0 to 10 based on their perceived impact on stream integrity. The 0 to 10 scale corresponds to None (0) to Severe (10) impact. A brief description of the type of data collected as part of the infrastructure inventory and impact descriptions are included below (descriptions are from the *Fairfax County Stream Physical Assessment Protocols,* February 2004 Revision).

Deficient Buffer Areas *(scale of 0 – 10)*: These are areas within 100 feet of the streambank that are not forested. Scores are assigned and recorded separately for each bank and are an indication of the impact the deficient buffer has on the stream channel.

- *Extreme (10)*– Impervious/commercial area is in close proximity to the stream. Stream banks may be modified or engineered. Stream character (bank/bed stability; sediment deposition, and/or light penetration) is obviously degraded by adjacent use.
- *Severe (7)* – Some impervious and/or turf only up to bank and water. There is very little vegetation aside from turf within the 25-foot zone. There may be a home site very close to stream. The stream character is probably degraded by adjacent use.
- *Moderate (5)* – Buffer encroachment is mostly from residential uses and lawn. There is some vegetation within the 25-foot zone, but very little aside from turf within the remainder of the 100-foot zone. The stream character may be changed slightly by adjacent use.
- *Minor (2)* – The vegetated buffer primarily consists of native meadow. (Not Grazed)

Good Condition

Poor Condition

Areas of Erosion *(scale of 0 – 10)*: These are areas of active erosion that are at least 2 – 3 feet high. The height and length, in feet, of erosion and impact scores are recorded separately for each bank separately.

- *Extreme (10)* – Impending threat to structures or infrastructure
- *Severe (7)* – Large area of erosion that is damaging property and causing obvious instream degradation. Eroding bank is generally five feet or greater in height.

- *Moderate (5)* – Moderate area of erosion that may be damaging property and is creating some instream degradation. Eroding bank is generally two feet or greater in height.

Good Condition

Poor Condition

Obstructions *(scale of 0 – 10)*: Obstructions that are causing erosion problems or are causing flooding of manmade structures are recorded. Beaver dams are included as obstructions but are scored as zero impact unless significant bank damage is evident. Notation is also made concerning the obstructions impact on fish passage.

- *Severe (10)* – Blockage is causing significant erosion problem and/or creating potential for flooding that can cause damage to infrastructure. The stream is usually almost totally blocked (greater than 75 percent blocked).
- *Moderate (5)* – Blockage is causing moderate erosion and could cause flooding. Stream is only partially blocked, but the obstruction should probably be removed because the problem could worsen.
- *Minor (3)* – Blockage is causing some erosion problems and has the potential to worsen and probably should be looked at and/or monitored.

Poor Condition

Dump Sites *(scale of 0 – 10)*: Dump sites include all areas where inappropriate materials have been disposed. Yard waste and other organic debris is included if it is directly in the stream.

- *Severe (10)* – Active and/or threatening sites. Dumpsite material may be considered toxic or threatening to the environment (concrete, petroleum, empty 55 gallon drums, etc.) or the site is large (greater than 2,500 square feet and appears active.
- *Moderate (5)* – Dumpsite is less than 2,500 square feet and is non-toxic material. The dump site does not appear to be used often, however clean-up would definitely be a benefit.
- *Minor (1)* – Dumpsite appears small (less than 1,000 square feet) and materials are stable (will not likely be transported downstream by high water). These sites are not considered a high priority.

Poor Condition

Head Cuts *(scale of 0 – 10)*: A head cut is an erosional feature in which a sudden change in stream bed elevation occurs resulting in a small waterfall feature. Flow over the headcut results in a lowering of the stream bed elevation on the downstream side. The headcut will migrate upstream creating a deeper channel as it porgresses. Only active head cuts were recorded.

- Head Cut height greater than two feet *(10)*
- Head Cut height is equal to two feet *(5)*
- Head Cut height is equal to one foot *(3)*
- Head Cut height is less than one-half-foot or is inactive *(1)* (not recorded)

Poor Condition

Pipes and Drainage Ditches *(scale of 0 – 10)*: All drainage pipes and ditches were recorded. Information on each includes size and distance from channel, material, discharge (if present), and source of discharge (if known). The impact score assigned refers to the impact that the pipe or ditch has on the stream channel.

- *Severe (10)* – Storm flows through ditch or pipe is causing a significant erosion problem to stream bank or stream and/or the discharge that is coming from pipe appears not to be stormwater.
- *Moderate (5)* – Storm flows through ditch or pipe is causing a moderate erosion problem and should be fixed. The problem may get worse if left unattended. OR Discharge may be coming from pipe, probably stormwater but cannot be sure without further investigation.
- *Minor (0)* – Storm flows through ditch or pipe is not causing erosion problem and no discharge is occurring.

Poor Condition

Public Utility Lines *(scale of 0 – 20)*: This includes all exposed utility lines and manholes. Information on utility type was also collected if known.

- *(20)* – Utility line is leaking.
- *(10)* – Exposed utility line is causing a significant erosion problem and/or obstruction (blockage) OR if sanitary line, potential to burst or leak appears high.
- *(7)* – Half exposed utility line is causing moderate erosion problem.
- *(5)* – Utility line is partially visible but mostly buried in stream bed. There is little if any erosion associated with the utility line.
- *(3)* – Utility line is exposed but is stabilized with concrete lining and stable anchoring into the bank.

Poor Condition

Road and Other Crossings *(scale of 0 – 10)*: All stream crossings, including foot bridges and man made fords were included. Information on upstream and downstream structural integrity and blockages was also included.

- *Extreme (10)* – Condition of debris, sediment, or erosion poses immediate threat to structural stability of road or other structure. Major repair will be needed if problem is not addressed.
- *Severe (7)* – Condition probably poses threat to road or other structure. Problem should be addressed to avoid bigger problem in the future.
- *Moderate (5)* – Condition does not appear to pose threat to road or other structure, but should be addressed to enhance stream integrity and future stability of structure.
- *Minor (2)* – Condition is noticeable, but may not warrant repair.

Poor Condition

3.2.6 Hydrology and Water Quality Modeling

Computer modeling of watershed processes is one of the key methods used to determine where there are problems and how effective a particular solution might be in correcting a problem. Hydrology modeling simulates how rainfall either infiltrates into the ground or runs off the land to enter the stream system. It provides a way to estimate the amount of runoff and the peak streamflow or **discharge** that results from changes in land use or stormwater management.

Water quality modeling is used to provide estimates of **pollutant loading** that can be used for planning. Three significant pollutants modeled for the Difficult Run Watershed Plan are total **nitrogen** (TN), total **phosphorus** (TP) and total **suspended solids** (TSS).

Hydrology and water quality were modeled for each subwatershed and **catchment** in the Difficult Run watershed. The models used in the plan incorporate data on the amount, character and location of the land use, impervious cover, topography, vegetation, streams, and stormwater management to generate estimates of water quality and streamflow.

Modeling of future conditions generally uses the same data inputs and estimates the same parameters but does so with future land use information. The future land use is a prediction of what the land would look like if the lots were all developed to the highest density allowed by their zoning classification. The difference between the existing and future model results identifies areas that will need additional management measures.

Modeling of hydrology and water quality was conducted throughout the Difficult Run watershed using the PCSWMM model for both existing and future conditions. The results will identify problem areas and areas in need of improvements. The modeling discussed for each subwatershed includes the following:

Runoff volume:	reported in inches per year
Peak discharge:	reported in cubic feet per second
Total Nitrogen:	reported in pounds per acre per year for both runoff and septic sources
Total Phosphorus:	reported in pounds per acre per year for both runoff and septic sources
Total Suspended solids:	reported in pounds per acre per year for both runoff and septic sources

A more complete description of the modeling procedures can be found in Appendix E.

3.2.7 Hydraulic Modeling

Modeling of stream flow or **hydraulics** was conducted throughout the Difficult Run watershed using the HEC-RAS model. The model combines topography with information concerning the stream system, the stream crossings and culverts to estimate the depth and speed of flow within the stream for various storm events.

Storm events are classified by the amount of rain that falls in 24 hours. The storms are then named by the probability of that storm event occurring within one year. The more rainfall in a storm, or the larger the storm event, the less likely it is to occur in any given year. Hence, a 1-year storm (likely to occur once every year) is smaller with less rainfall than a 10-year storm (likely to occur once every ten years).

Flooding occurs at road crossings when the crossings are not large enough to pass the streamflow during a storm. For larger roads that carry through traffic, called primary roads, the crossing must be large enough to permit the 25-year storm event to flow completely through it without flowing over, or overtopping, the road. For smaller roads used for access to residences or other local areas, identified as local roads, the crossing must permit the 10-year storm event to pass completely through.

The model results indicate where flooding of culverts and other structures may occur. The flow at these sites exceeds the capacity of the culvert. These sites can present a hazard and are considered candidate sites for improvement, further study and possibly a project to replace or retrofit the culvert.

3.3 Candidate Sites for Improvements

Candidate sites are those sites, stream reaches, or catchments that were identified to have a degraded condition and are potential areas for restoration. Additionally, areas that are currently in good condition but are vulnerable in the future due to changes in land use were selected as candidate sites for preservation. The full procedure used in the prioritization and selection process is located in Appendix G.

Candidate sites were selected from a combination of existing data sources, stream assessment data, model results and GIS data. The procedure consisted of using

quantifiable indicators that describe the condition of the watershed with limited overlap, weighting them by importance, and then calculating a weighted average score for each area. This score is then used to rank them in priority order for restoration or preservation. Problems or overall condition were ranked and three different scales; sites, stream reaches and catchments.

A total of 253 candidate sites were selected for further field review and analysis based on the prioritization of problems in the catchments and at stream sites. Candidate sites were placed in several categories. The categories are listed below with its identifying code letter.

- Stream Restoration sites (S),
- Catchment sites (C),
- Regional pond alternatives sites (D),
- Flooding sites for roads (F) and
- Preservation sites (P).

Stream Restoration

A total of 88 Stream Restoration Sites were selected. Data from the Stream Physical Assessment were used to determine which sites were in the poorest conditions. Sites were typically selected if they showed two or more impairments in either habitat rating, channel morphology, stream erosion, bank stability, or riparian buffer. Notes on restoration potential recorded during the assessment were also taken into account.

Catchments

The 201 catchments in the Difficult Run watershed were ranked based on existing conditions using modeled peak discharge, runoff volume, nitrogen, phosphorus, suspended solids, and GIS calculations of the percent of the catchment in wetlands and forests. Each of the parameters was normalized according to the specific needs of the indicator and compiled into a single database. The value for each parameter was ranked within the range of values in the dataset. Scores from 1-10 were then applied to the ranked values.

The score for each catchment was then multiplied by the indicator weight to develop the weighted score. The weighted scores for all of indicators were then summed and placed on a 0-100 scale. Each catchment's scaled score was then ranked within the 201 catchments. The lowest score indicates the lowest relative quality and the highest priority in the watershed. A total of 46 catchment sites received the lowest scores and were subsequently selected for restoration.

Regional Pond Alternatives

There are 52 known sites where Regional Ponds were planned but have not yet been built in Difficult Run. During the modeling task, the drainage area to each of these sites was delineated as one or more separate catchments, so it was possible to rank the unbuilt regional pond sites using the same prioritization scheme as the other areas of Difficult Run. Ranking results have been included with the catchments.

Flooding Sites for Road Crossings

Hydraulic modeling identified the culverts that were overtopped by any of the modeled storm years (1,2,5,10,25,50,100). The overtopping was then compared to the level of service for that road and the associated required flow that the road must pass. If the culvert did not pass the required flow it was selected as a candidate site. There were 89 culverts that overtopped for one or more storm flow, 34 were selected as candidate sites.

Preservation

A comparison between existing and future conditions model results was made to generate a ranking of vulnerability. The catchments that showed low pollutant loading for existing conditions and a large percent change between existing and future conditions were considered the most vulnerable to degradation and thus good candidates for preservation.

The threshold values for TSS, TN, and TP were used to determine good conditions. These were based on comparisons with values for the whole watershed, and with estimates of loadings from "irreducible concentrations" from stormwater runoff (Schueler, 2000). Values used to set the thresholds are shown in Table 3.3, in lb/ac/yr.

Table 3.3: Threshold Values for Preservation Candidate Sites

	TSS	TN	TP
Low	17.8	0.9	0.18
Average	63.1	2.8	0.41
High	197.9	7.9	0.92
Irreducible	20 to 40	1.9	0.20
Threshold	30.0	2.0	0.20

The percent change between existing and future loads was calculated. If one or more of the paramenters doubled (increase of 200% or more), then the catchment was flagged as a preservation candidate.

Similar to the existing conditions catchment ranking, the score for each catchment was multiplied by the indicator weight to develop the weighted score. The weighted scores for all of indicators were then summed and placed on a 0-100 scale. Each catchment's scaled score was then ranked within the 201 catchments. The lowest score indicates the highest vulnerability and the highest priority in the watershed for preservation. A total of 34 catchment sites were selected.

3.3.1 Approach to Project Selection

The first step in developing stormwater management or other restoration alternatives was to determine the objective for each candidate site. This was usually clear from the type of impairment, and included such things as reducing peak flows, pollutant loads, erosive streamflows, or the amount of runoff.

Following this step, field surveys were made to determine if there were any site constraints which would prevent certain types of improvements from being implemented, or opportunities that would make others more likely to be successful.

While in the field, project staff made recommendations for improvements using the following basic approach. The approach works upstream to downstream, and should provide reduction in erosive streamflows so that when any stream restoration projects downstream are designed, they should be less complex and more likely to be successful.

- Locate projects in the headwaters of the stream to reduce runoff quantity and provide quality control if possible. These types of controls could include:
    - retrofits of existing stormwater management facilities for extended drawdown and channel protection
    - new stormwater management facilities or culvert retrofits
    - LID retrofit practice such as infiltration or porous pavers
- Identify locations for water quality controls, such as the following:
    - Retrofits of existing facilities for water quality control
    - Installation of LID controls in older watershed areas

    - LID retrofits practices such as bioretention or filtration
- Identify stream restoration projects
    - Stream restoration
    - Buffer restoration

There were a number of occasions where no projects resulted even after a catchment or stream reach was identified as a candidate site. For catchment sites, this generally occurred because there were no retrofit measures which appeared feasible, because of topography, lack of available land, land ownership, or the type of development in the catchment. For stream restoration sites, typically the constraints such as forest clearing outweighed the potential benefits or the stream conditions had changed in the time between the Stream Physical Assessment and the field investigation for this plan.

3.4 Subwatershed Actions

The proposed actions are based on the recommendations of the project team with guidance from the community. They are organized by subwatershed and type of project, as follows:

Table 3.4: Recommended Project Types

Regional Pond Alternatives	Projects to retrofit areas without stormwater management, such as conversion of existing quantity controls to water quality BMPs; new structures such as ponds, wetlands, culvert retrofits, outfall treatments, and onsite systems designed to reduce stormwater impact at the lot level
Catchment Improvements	Projects to retrofit areas to reduce stormwater impacts, including the same types of projects recommended for unbuilt regional pond sites
Stream Restoration	In-stream projects, such as channel stabilization or riparian buffer restoration
Road Crossing Improvements	Projects designed to reduce the frequency of flooding of culverts and bridges
Non-structural Measures	Pollution prevention and programs to reduce pollutants from non-stormwater discharges
Preservation	Areas of high quality habitat or land cover that should be preserved as the area is developed in the future. Specific programs are described in Chapter 4.

A brief summary of each candidate site and the resulting projects are provided for each subwatershed. The projects are listed with the Impairment, Improvement Goals, the Site Investigation results and the Projects and Actions that are generated.

The following sections provide a short description of each type of project that is proposed. Table 3.5 at the end of the descriptions provides more detail on the benefits that can be anticipated from the project types.

Stormwater Pond Retrofits

Description Stormwater ponds are designed to improve water quality by increasing pollutant removal. The amount of water treated (water quantity) can be improved by increasing the time the stormwater stays in the pond, making the pond bigger, and/or adding to the land area that drains to the pond. The addition of wetlands adds habitat, in addition to improving water quality.

Practices Retrofitting existing stormwater management ponds to increase pollutant removal includes:

- Adding small pools within the larger pond
- Creating multiple pond cells within a single pond
- Creating wetland areas within the pond
- Creating a forebay to capture sediment before it enters the pond
- Reconfiguring the pond and the landscape to capture more stormwater

Figure 3.2 Wet Pond

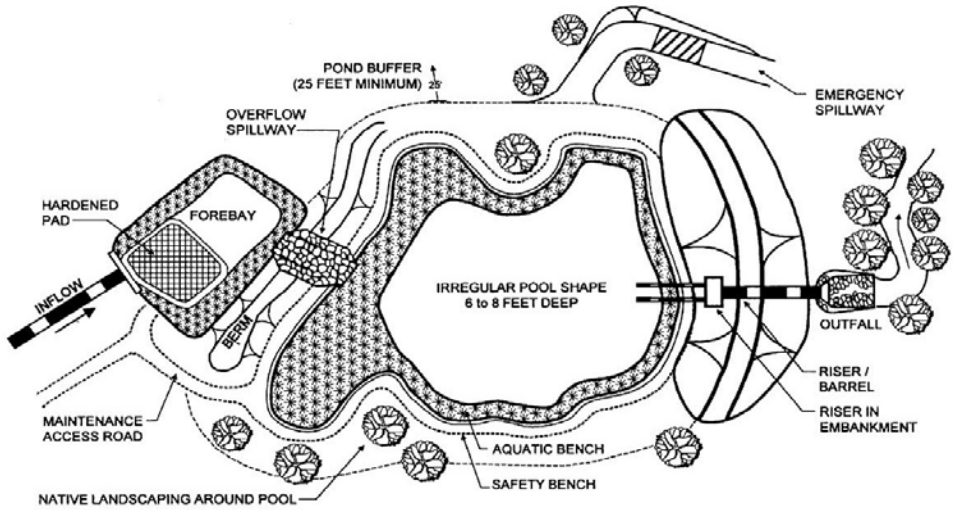
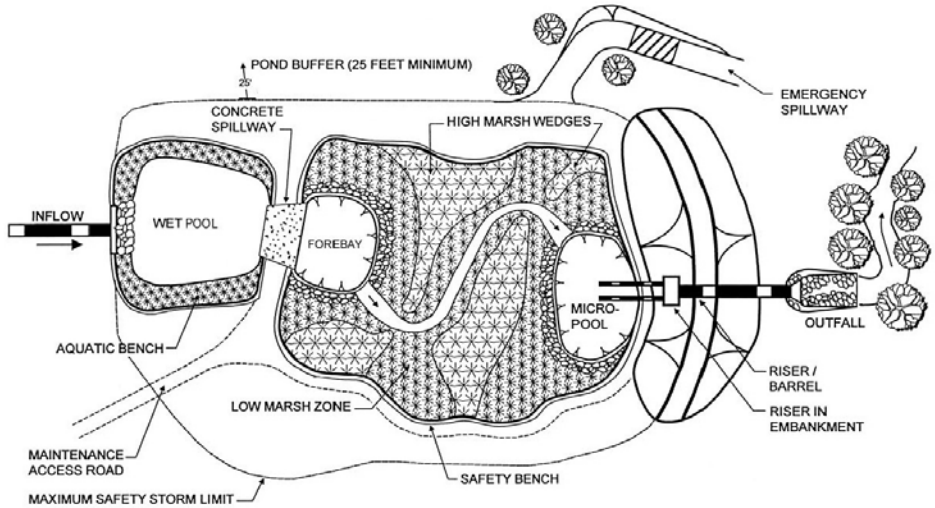


Figure 3.3 Pond/Wetland System



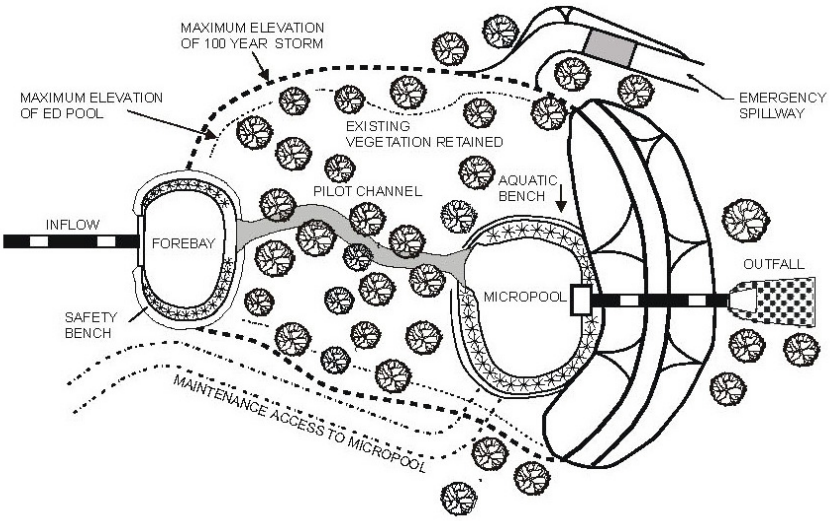
Source: *Maryland Stormwater Design Manual, Volumes I & II*. Performance Criteria for Urban BMP Design. Maryland Department of the Environment, 2000.

New Ponds

Description New ponds are designed to help reduce the impacts of stormwater runoff by either permanently or temporarily storing the water. This reduces both the amount of runoff delivered to receiving streams and the timing of that delivery. This helps to protect streams from land use changes in their watersheds. New ponds also improve water quality by allowing pollutants to settle.

Practices Wet ponds provide the most pollutant removal followed by extended detention and dry ponds. Extended detention ponds store runoff temporarily after a rainfall event. Extended detention ponds may have a permanent pool, be dry, or contain a wetland marsh. Dry ponds release stormwater runoff slowly after a storm event and provide temporary storage.

Figure 3.4 Micropool Extended Detention Pond



Source: *Maryland Stormwater Design Manual, Volumes I & II*. Performance Criteria for Urban BMP Design. Maryland Department of the Environment, 2000.

Stream Restoration

Description Stream restoration takes a holistic view of the stream system in the context of its watershed and addresses improvements to the stream bed, streambanks, and the low flow or aquatic channel. The goal of stream restoration is to return the stream to a stable state in which it neither significantly erodes or fills with sediment and has improved habitat conditions.

Practices Five treatment options are proposed in the plan, based on the type of impairment and constraints such as availability of adjacent land. The treatment options for each stream restoration project are specified in the concept plans included in Volume 2 of the watershed plan. For all of these projects, structures based on natural stream bed forms are created if necessary. Bioengineering techniques, and in some cases more traditional treatments, are used to provide for non-erosive stream banks. Wood and stone structures can be used to concentrate stream flow to the center of the channel to provide a good flow depth for aquatic life between storm events.

<u>Treatment Options for Incised Streams (CEM Type II)</u>

1. Option 1 creates a new meandering channel on a new alignment at its original floodplain elevation. The abandoned incised channel is either filled or converted into wetland ponds. This option is the most effective at restoring historical floodplain functions.
2. Option 2 creates a new, meandering channel with a new floodplain built at an elevation lower than the original floodplain elevation. This option does not reconnect to the original floodplain lost due to incision, but creates a new floodplain at a lower elevation. The new channel typically follows the general alignment of the incised channel, but with a stable planform.

<u>Treatment Options for Incised Streams (CEM Type II) or Widening Streams (CEM Type III)</u>

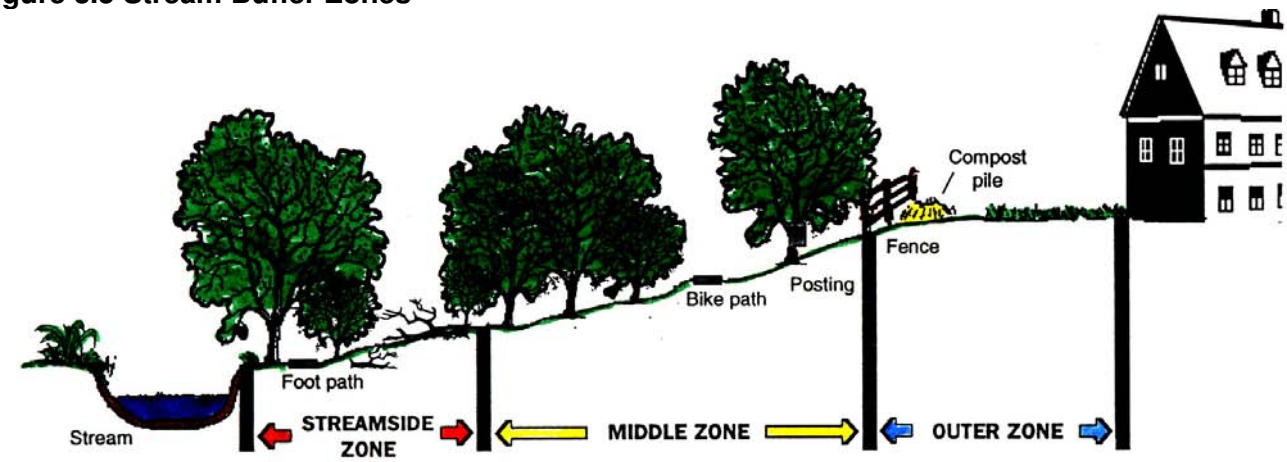
3. Option 3 stabilizes the channel by converting to a more stable stream type. Typically, these projects include, adjusting cross-section, reducing bank slope, and creating a new floodplain bench. This alternative includes different treatments for Type II and Type III streams. For incised channels with no room to increase meander width, Treatment 3A includes using grade controls to stop incision, flatten the slope of the stream and dissipate stream energy. For either incised or widening streams, Treatment 3B involves grading the banks and creating a nested channel with a new floodplain similar to a CEM Type V within the incised or widened streambed.
4. Option 4 stabilizes channels at the existing bed elevation and along the existing alignment. These projects are proposed where options 1-3 are not feasible. This approach is the traditional armor in-place approach to address incised channels and bank erosion. Treatment 4A involves grading and earthwork to lay back oversteepened banks and create a more stable cross-section. Treatment 4B is the traditional armor-in-place approach, with imbricated rip rap or bioengineering materials.
5. Option 5 projects consist of excavating the existing channel and reconstructing a new low-flow channel as part of a SWM facility providing storage volume to provide channel protection and water quality improvements downstream.

Stream Buffer Restoration

Description The vegetated land area on either side of a stream is referred to as the stream or riparian buffer. Buffers can be comprised of grasses, shrubs, trees, or a combination of the three. Forested buffers provide streambank stability, food for aquatic life, and shading of the stream. Stream buffers also provide important wildlife habitat. In many urban areas, stream buffers have been impacted. Restoring vegetation to these areas can improve the quality of the stream. Buffer restoration projects can be incorporated into streambanks stabilization and stream restoration projects to encourage multiple water quality and habitat benefits.

Practices The three types of buffer restorations are water pollution hazard setbacks, vegetated buffers, and engineered buffers. Water pollution hazard setbacks are areas that may create a potential pollution hazard to the waterway. By providing setbacks from these areas in the form of a buffer, potential pollution can be avoided. Vegetated buffers are any number of natural areas that exist to divide land uses or provide landscape relief. Engineered buffers are areas specifically designed to treat stormwater before it enters into a stream, shore or wetland.

Figure 3.5 Stream Buffer Zones



CHARACTERISTICS	STREAMSIDE ZONE	MIDDLE ZONE	OUTER ZONE
FUNCTION	Protect the physical integrity of the stream ecosystem	Provide distance between upland development and streamside zone	Prevent encroachment and filter backyard runoff
WIDTH	Min. 25 feet, plus wetlands and critical habitats	50 to 100 feet, depending on stream order, slope, and 100 year floodplain	25 foot minimum setback to structures
VEGETATIVE TARGET	Undisturbed mature forest. Reforest if grass	Managed forest, some clearing allowable	Forest encouraged, but usually turfgrass
ALLOWABLE USES	***Very Restricted*** e.g., flood control, utility right of ways, footpaths, etc.	***Restricted*** e.g., some recreational uses, some stormwater BMPs, bike paths, tree removal by permit	***Unrestricted*** e.g., residential uses including lawn, garden, compost, yard wastes, most stormwater BMPs

Source: Stormwater Manager's Resource Center www.stormwatercenter.net/

Road Crossing Improvements

Description Culverts and bridges that can be flooded during a storm event may need improvements to reduce the frequency of flooding. Road crossings that were identified as having flooding problems based on hydraulic modeling have been compiled in Appendix F for further coordination with the Fairfax County Department of Transportation and the Virginia Department of Transportation.

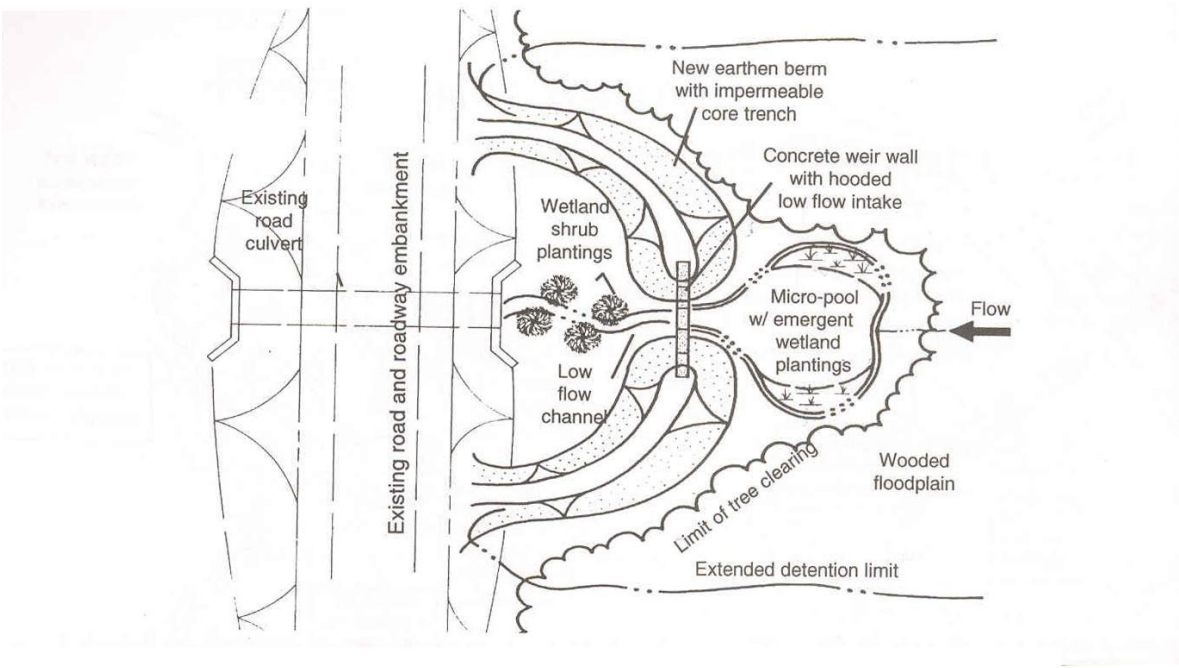
Practices These improvements can include raising the roadbed above the flood level, rebuilding culverts so they can pass more water, replacing worn or damaged culverts that impede water with newer ones that allow water to flow more quickly, or rebuilding bridges with a wider span to allow more space for floodwaters to pass.

Culvert Retrofits

Description This retrofit option is installed upstream from existing road culverts by constructing a control structure and excavating a micro-pool. These projects are usually designed for intermittent streams. The control structure will detain and reduce stormwater flow; the micropool is a small pool that will infiltrate the first 0.1 – 0.2 inches of stormwater runoff, improving water quality.

Practices If the upstream area is an open floodplain, it may be possible to construct a wet pond or stormwater wetland to improve water quality treatment. Since roadways are not always constructed as pond embankments, special measures may be necessary, such as a redundant embankment built upstream of the culvert. Secondary impacts need to be considered as well, including impacts to the 100-year floodplain, fish passage barriers, or impacts to wetlands and forest.

Figure 3.6 Culvert Retrofit



Source: Stormwater Manager's Resource Center www.stormwatercenter.net/

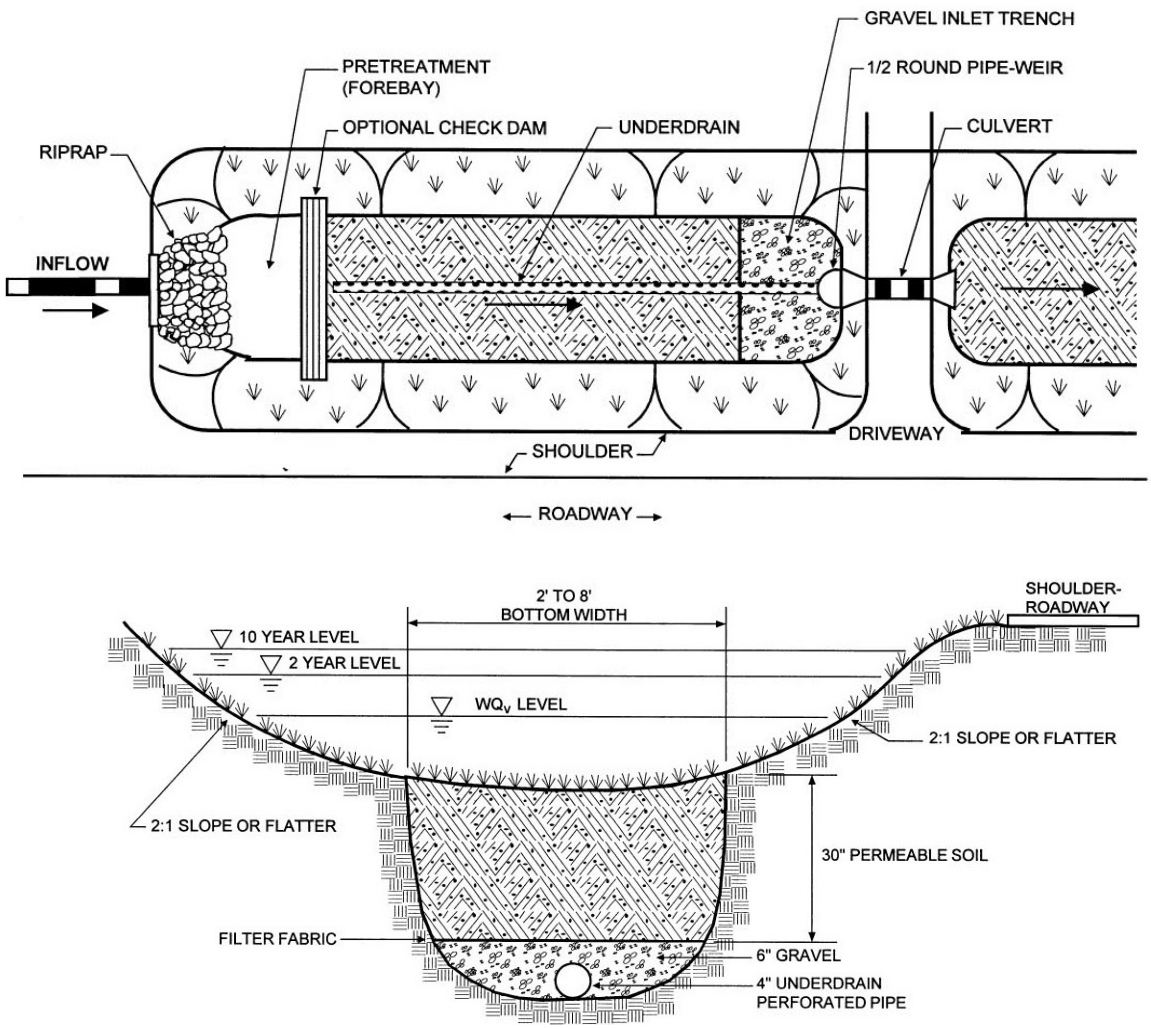
Drainage Retrofits

Description Drainage retrofits are designed to protect the natural stream channels in the watershed from fast draining water. These retrofits reduce the energy of the water flowing into and through streams, than can cause unstable streambeds and banks and erosion.

Practices Two basic types of retrofits are proposed. The first is to improve outfall structures to provide more energy dissipation and reduce scour and erosion. Methods include placement of rip rap, design of a plunge pool to break the flow of water, or provision of a designed energy dissipation structure which adds turbulence to reduce the velocity of the outfall discharge.

The second type is removal and replacement of concrete channels as roadside stormwater conveyances. Retrofit with grass channels, wet swales, or dry swales would increase stormwater detention time and reduce peak flows at the outfall.

Figure 3.7 Dry Swale



Source: *Maryland Stormwater Design Manual, Volumes I & II*. Performance Criteria for Urban BMP Design. Maryland Department of the Environment, 2000.

Low Impact Development (LID) Retrofits

Description LID systems are designed to provide stormwater management on the site where runoff is generated, usually providing some reduction in stormwater, detention to reduce peak flows, and water quality treatment. The main objective is to mimic the pre-development runoff characteristics of the site.

Practices LID systems that could be retrofit in the Difficult Run watershed include bioretention, infiltration, filter strips, sand filters, dry swales, wet swales, porous pavers, or proprietary filtration and bioretention systems.

Figure 3.8 Infiltration Trench

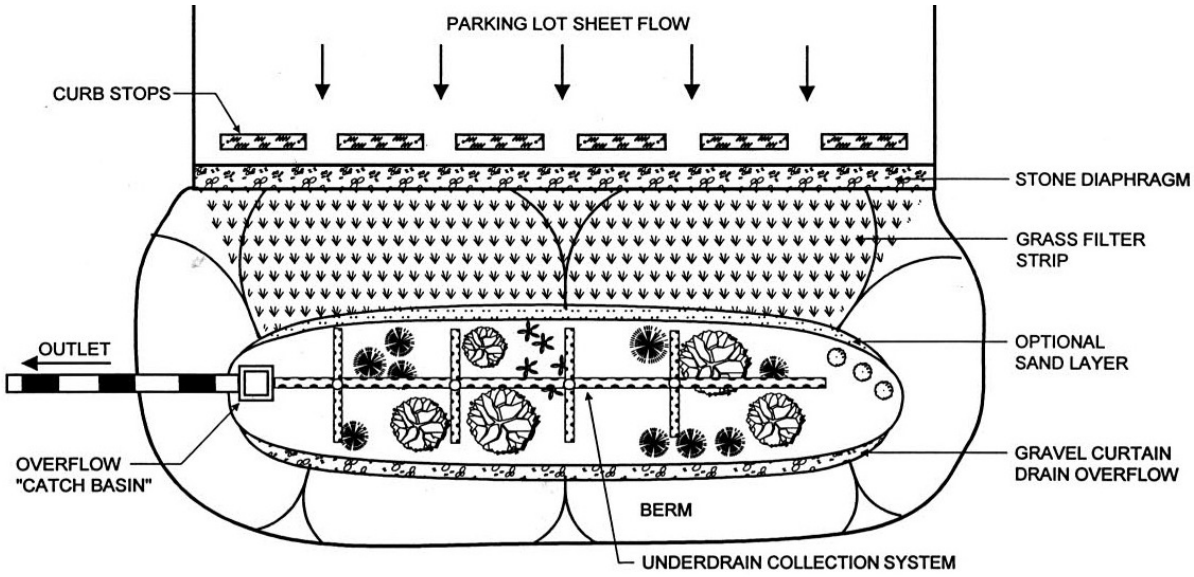


Figure 3.9 Bioretention

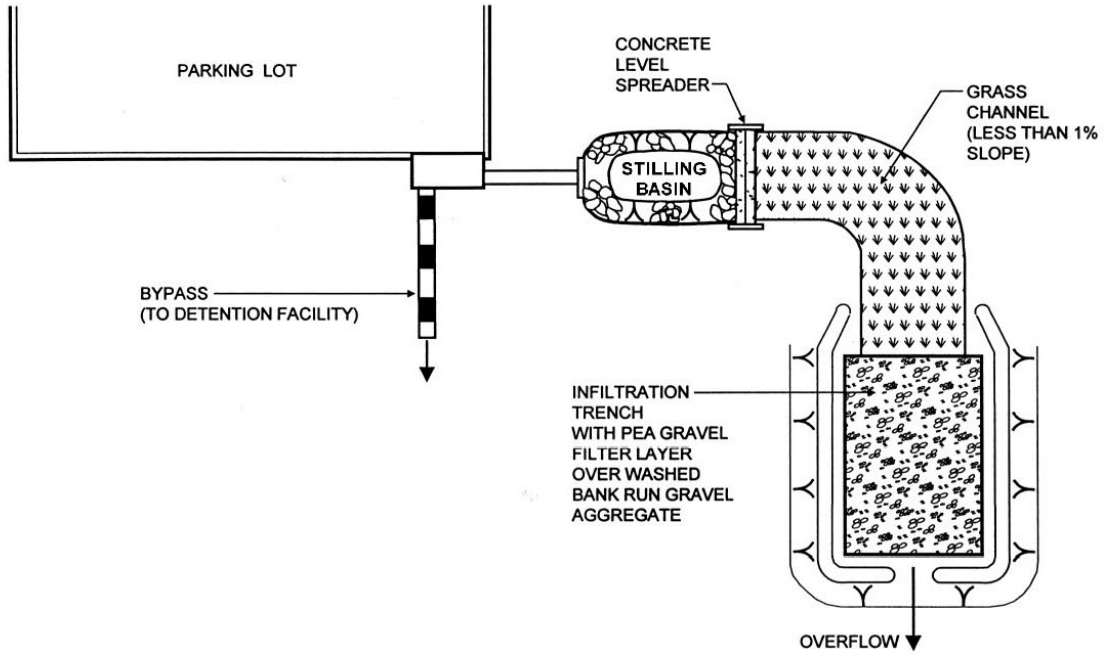


Figure 3.10: Sand Filter

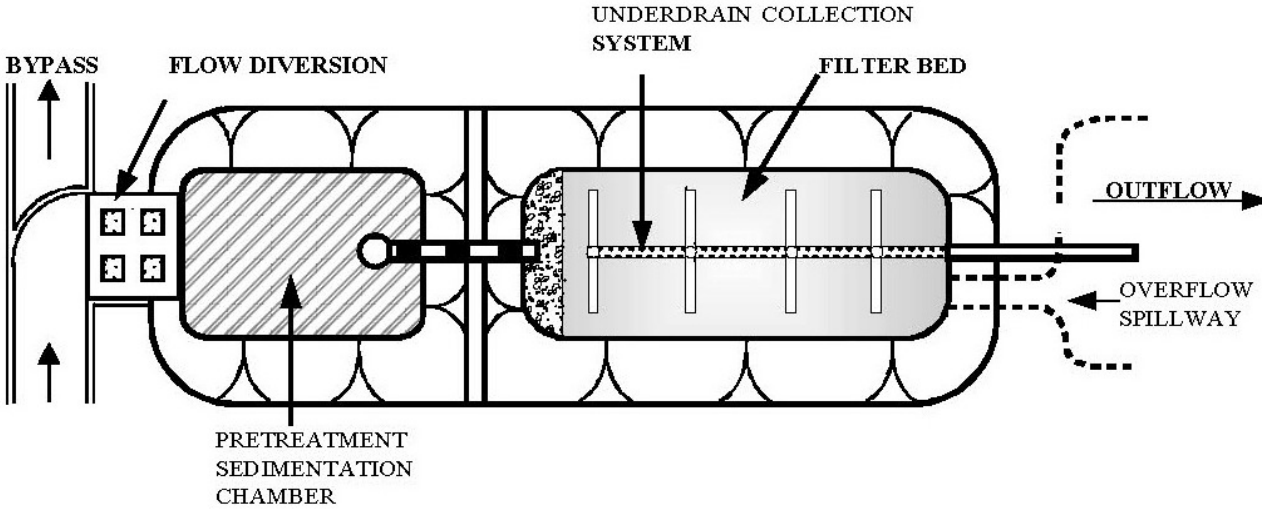
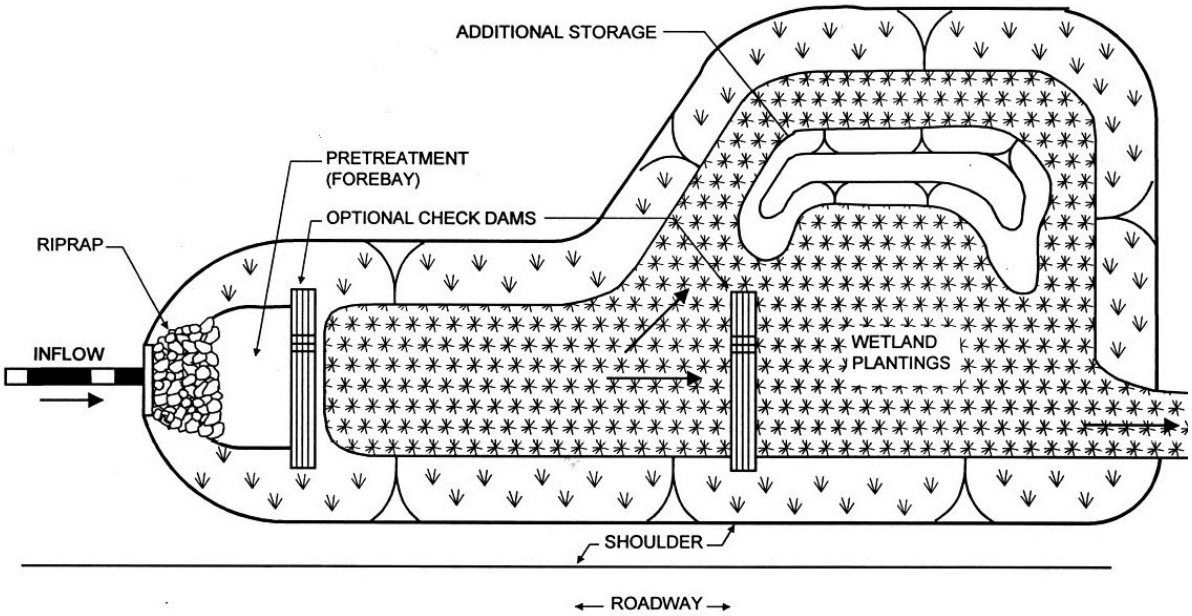


Figure 3.11: Wet Swale



Source: *Maryland Stormwater Design Manual, Volumes I & II*. Performance Criteria for Urban BMP Design. Maryland Department of the Environment, 2000.

Table 3.5: Benefits of Project Types

Category	Type	BMP	Flow Control	Water Quality	Aquatic Habitat	Channel Morphology
New Ponds	Ponds	Micropool ED Pond	2	1		
and Retrofits		Wet Pond, Wet ED Pond	1	2		
	Wetlands	Wetland / Shallow Marsh	2	1	3	
		Pond/Wetland System	2	1	3	
		ED Wetland	1	2		
Streams	Stream Restoration	New Alignment		3	2	1
and Buffers		Re-align Existing Channel		3	2	1
		Stable Stream Type		3	2	1
		Bank Stabilization		3	2	1
	Buffer Restoration	Buffer Restoration		3	1	2
	Watershed-Wide	Dumpsites		2	1	
		Obstructions			1	2
		Fish Passage Restoration			1	2
		Utility Crossings			1	2
Culverts	Road Crossings	Road Crossing			2	1
	Culvert Retrofit	Culvert Retrofit	1	2		
Drainage	Swales	Grass Channel / Dry Swale		1		
Retrofits		Wet Swale		1		
	Outfall Retrofit	Outfall Stabilization			2	1
LID	Filtration	Sand Filters		1		
Retrofits		Organic Filter		1		
		Bioretention / Rain Gardens	2	1		
	Infiltration	Infiltration Basin	1	2		
		Infiltration Trench	1	2		
	Disconnection	Porous Pavement	1	2		
		Rain Barrel / Cistern	1	2		
		Green Roof	1	2		
	Other WQ BMPs	WQ Inlets		1		
Watershed-		Dumpsites		2	1	
Wide		Obstructions			1	2
Projects		Fish Passage Restoration			1	2
		Utility Crossings			1	2
Benefits	1	Primary benefit				
	2	Secondary benefit				
	3	Supplemental benefit				