Maryland State Highway Administration
Stormwater Management Site Development Criteria

SHA State Highway Administration
Maryland Department of Transportation

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Section 1 - Introduction

1. Introduction

The Maryland State Highway Administration (SHA) promotes environmental stewardship and sustainability in many of its efforts. Managing stormwater is a critical component of environmental sustainability to maintain and improve the quality of our watersheds and the Chesapeake Bay. Stormwater Management (SWM) Best Management Practices (BMPs) address both water quantity and quality treatments. The Maryland Department of the Environment (MDE) regulates stormwater management practices as outlined in the *2009 Maryland Stormwater Design Manual.*

Context sensitive solutions are efforts incorporated in the planning, design and construction process that tailors an individual project to address specific needs related to its surroundings. Because each project has a unique situation, a one-size-fits-all approach is not applicable. The site development process includes analysis of unique features and conditions on a project-by-project basis, and develops individualized solutions specifically for the given situation. Utilizing context-sensitive solutions serves as measures of stewardship and improves environmental sustainability and aesthetics.

SHA has developed criteria to address context-sensitive measures for stormwater management facilities. The criteria provided in this document is meant to challenge stormwater design professionals to consider situational factors beyond the standards set forth in the *2009 Maryland Stormwater Design Manual*. This document has been developed to assist stormwater designers to incorporate safety, sustainability, visual and environmental quality features into stormwater management (SWM) facilities. It is important that SWM facilities fit within the surrounding environmental and community context. It is also important to protect the public from safety hazards associated with the functioning of these facilities and to ensure that these facilities can be properly maintained into the future. The SWM site development criteria have been developed in order to ensure these concerns are addressed. However, the manner in which an individual project is designed and built should be done with an approach that addresses the project's unique circumstances.

This site development criteria (SDC) includes:

- Safety – includes safety for field inspectors, maintenance personnel, motorists and the public.
- Sustainability – means that the facility is able to be maintained and is built in a manner to get the longest service life.
- Visual quality – addresses the appearance of the facility and includes grading and landform design, detailing at site structures such as stormwater outfall structures, fencing, riprap and planting design.
- Environmental quality – looks at the benefits or impacts the facility may have on water quality, critter habitat, thermal reduction, or other environmental conditions.

Section 2 - Stormwater Management Considerations




2. Stormwater Management Considerations

Each SWM facility needs to meet the unique project requirements and conditions. In order to determine the appropriate type of facility, location, and design features, the designer must have a full understanding of all factors and considerations that may affect the facility.

2.1 Appropriateness of BMP Type

The following considerations can affect the type of facility proposed:

Type and Location – Consider watershed, terrain, treatment suitability, physical feasibility, community, environment, and permits. Refer to the following chapters of the *2009 Maryland Stormwater Design Manual:*

- Chapter 2: Unified Stormwater Sizing Criteria
- Chapter 3: Performance Criteria for Urban BMP Design
- Chapter 4: Guide to BMP Selection and Location in the State of Maryland
- Chapter 5: Environmental Site Design
- Appendix A: Landscaping Guidance for Stormwater BMPs
- Appendix. D.3: Short Cut Method for a Wetland Drawdown Assessment.

Surrounding Context – Other factors to consider are proximity to residential, recreational, commercial or institutional areas. Standing water can become a breeding ground for mosquitoes, which can become a nuisance to the surrounding community. Visual quality can be paramount in certain contexts to ensure that the facility blends with the surroundings and to ensure that SHA remains a good neighbor within the communities we serve. The Site Development Criteria Reviewer will identify projects where the surrounding context necessitates for special circumstances and design decisions to address community concerns.

Scenic Byways – Refer to the Maryland Scenic Byways map to determine if the site is within a scenic byway corridor and in need of special aesthetic considerations. Scenic byway corridors are loosely defined as the area within the viewshed of a scenic byway route, or within one mile of the right of way if the viewshed is expansive. Local jurisdictions prepare a corridor management plan with specific guidelines and strategies for each scenic byway to preserve and enhance its character. See ***Appendix A*** for a map of scenic byway routes in Maryland. Also, refer to the *Maryland Scenic Byways Context-Sensitive Design Guidelines* and coordinate with the Landscape Architecture Division (LAD).

Open section roadway with narrow, vegetated channels suits the context of this scenic byway. Photo Credit: Flickr.com

Wild and Scenic Rivers – The Maryland General Assembly has designated nine rivers as scenic and one river as wild in Maryland. The nine scenic rivers include the Anacostia, Deer Creek, Monocacy, Patuxent, Pocomoke, Potomac (Frederick and Montgomery Counties), Severn, Wicomico-Zekiah, and Youghiogheny Rivers. The section of the Youghiogheny between Millers Run and the southern corporate limits of Friendsville has been officially designated a "Wild" river. The Maryland Department of Natural Resources (DNR) prepares a management plan for each designated river for preservation and management strategies of river related resources. Special attention should be made to context-sensitive design within these watersheds to preserve the character and water quality. For more information, please refer to the following:

Scenic River integrity depends on water quality and volume management as well as aesthetic considerations.

http://www.dnr.maryland.gov/land/stewardship/scenicrivers.asp.

Stormwater Hotspots – It should also be determined if the site is located in a SWM Hotspot as defined in the National Pollution Discharge Elimination System (NPDES) *Standard Procedures Manual* and in *Chapter V of the 2009 Maryland Stormwater Design Manual*. These are usually located in heavily industrialized areas, or other locations with a high potential for pollutant runoff. This may affect the type of facility selected to ensure water quality measures are effectively addressed.

Proximity to Airports – Elimination of bird strike potential and other wildlife hazards at and in the vicinity of airports affects the choice of stormwater facility type and planting choices. Generally, wet pools, wetlands and wet swales are not permitted in these areas and any plant material that is used must have low wildlife value.

Check proximity to airports, particularly Martin State Airport and BWI-Thurgood Marshall Airport, which have Airport Zoning Districts. See ***Appendix B.1*** and ***B.2*** for the Airport Zoning District locations. Verify that facility types in these zones meet Maryland Aviation Administration (MAA) restrictions or restrictions at local and military airports. Refer to *MAA Design Standards – Bird Deterrent Systems (DST-2001-09)*, *Exhibit 'A': MAA Criteria for Stormwater Management within the BWI Airport Zone* and the latest listing Approved Plants for BWI and/or Martins Airports (Appendix to the

Aircraft bird strikes or other wildlife impacts can cause serious safety concerns; therefore, SWM facilities near airports should not attract wildlife. Photo Credit: Flickr.com

Specifications for Performing Landscaping Activities for the Maryland Aviation Administration).

Federal Aviation Administration (FAA) restrictions apply to other airports such as Andrews Air Force Base and the Patuxent Naval Base. FAA generally requires a 5-mile radius (see ***Appendix B.3*** and ***B.4***) for airport zoning districts. Additional information is found on the FAA website at www.faa.gov including Advisory Circulars and CertAlerts specific to wildlife issues.

Appendix B includes a map of the BWI-Thurgood Marshall Airport and Martin State Airport Zoning Districts as well as a 5-Mile radius from Andrews Air Force Base and Patuxent Naval Station as required by FAA. Airport considerations should also be given to other county, municipal and private airfields around the State.

Stream Use Classification – Watershed stream use classifications for use III and IV streams have additional design requirements. These watersheds have shortened extended detention times and require attention to thermal impacts that facilities might impart to receiving waters. Facilities with no permanent pools may be required. Special plantings that provide shade or underground storage may reduce thermal impacts. (See *Appendix D.9* of the *2009 Maryland Stormwater Design Manual* for stream use designations.)

Pollutant Discharge Elimination – The Clean Water Act dictates a total maximum daily load (TMDL) of pollutants for certain impaired watersheds. Projects must apply for either an individual permit or general permit through the National Pollutant Discharge Elimination System (NPDES). The type of permit depends on the size of the impacted area and if the stormwater will discharge into an impaired watershed. Permit conditions may require mitigation measures and monitoring to improve water quality within the receiving waters. Refer to www.mde.maryland.gov/Programs/WaterPrograms/TMDL/ for more information.

Critical Areas – Chesapeake Bay Critical Area are defined as all water and submerged lands of the Chesapeake Bay to the head of tide, and all land and water within 1,000 feet of mean high water or from the edge of tidal wetlands (see Appendix D.4 of the *2009 Maryland Stormwater Design Manual* for Stormwater Criteria for Maryland Critical Area IDA Zone). If the project is within the Critical Area, additional mitigation is required by the Critical Areas Commission. These additional requirements may impact type of facility proposed and the landscaping requirements. Refer to www.dnr.state.md.us/criticalarea/ for more information.

Areas within 1000 feet of tidal waters are a part of the Chesapeake Bay Critical Area where additional requirements apply. Photo Credit: Flickr.com

Coastal Bays – The Coastal Bays Program protects the land and waters of Assawoman, Isle of Wight, Sinepuxent, Newport, and Chincoteague bays. To the east of Route 113, the 175-square-mile watershed of the coastal bays includes Berlin, Ocean City, parts of Snow Hill and Pocomoke and the Assawoman, Isle of Wight, Sinepuxent, Newport, and Chincoteague bays. See ***Appendix C*** for a map of the Coastal Bays watershed and refer to www.mdcoastalbays.org for more information. If the project is within this watershed, refer to the latest Coastal Bay development criteria for recommended practices related to stormwater management, such as the *Recommended Model Development Principles for Worcester County,* which can be found online at: www.mdcoastalbays.org/archive/2007/Finalconcensusworcester.pdf.

Severn River Watershed – Anne Arundel County Soil Conservation District (AASCD) and the Severn River Commission have additional erosion and sediment control guidelines that apply to any project within the Severn River Watershed. This watershed is also designated as a scenic watershed, so aesthetic considerations are also important. Please refer to ***Appendix D*** for a map of the Severn River Watershed and the Severn River Commission website at www.aacounty.org/SevernRiver/index.cfm or the AASCD website at aascd.com for more information.

Special Protection Areas (SPAs) – A SPA is a geographic area that has high quality or unusually sensitive water resources and environmental features that would be threatened by proposed land development if special water quality protection measures were not applied. SPAs are designed by Montgomery County, and any special stormwater requirements unique to these areas would be imposed by Montgomery County. Additional stormwater controls for these areas are not required by SHA but good environmental stewardship is always encouraged. See ***Appendix E*** for a map of SPA locations and refer to www.montgomerycountymd.gov/content/dep/SPA/home.asp for more information.

Hazardous Materials – Sites that contain hazardous material contaminants may be found throughout the state. Soil or water testing may confirm presence of hazardous materials. Stormwater facilities that are designed to infiltrate or have contact with the ground water table should not be used in locations where hazardous materials are found. It is preferable to avoid locations where hazardous materials are found, or to use a pond liner. Pond liners can avoid the transfer of contaminants off site and into water. Coordinate with the SHA Environmental Planning Division (EPLD) to confirm results of an Environmental Assessment and any requirements related to hazardous materials avoidance or mitigation.

Sink hole damage along a major urban thoroughfare. Photo Credit: Flickr.com

Karst Topography - Karst topography is a landscape shaped by the dissolution of soluble bedrock, usually carbonate rock such as limestone or dolomite. Areas with karst topography are prone to sinkholes, which can cause significant property damage or

safety concerns. Pooled water from a stormwater management facility may increase bedrock dissolution and cause sinkholes to form. Areas known to have karst topography should be avoided or should be designed with a pond liner or to be a dry facility.

2.2 Volume Considerations

Over-Capacity – The SWM report should document facility sizing requirements to identify the potential for adjusting landforms, shape, and slope steepness if necessary. Capacity computations will note if the facility is oversized. If more water quality volume (WQv) or channel protection volume (CPv) treatment is provided than is required, there may be the potential to make adjustments. Landform adjustments may also be accommodated on sites that do not have over-capacity without reducing size, depending on the site conditions.

Environmental Site Design (ESD) – *Chapter V* of the *2009 Maryland Stormwater Design Manual* outlines requirements for ESD and low-impact development (LID) strategies for stormwater management. ESD focuses on mimicking pre-development drainage patterns and treating runoff closer to its source. This approach includes optimizing conservation of natural features, minimizing impervious surfaces, reducing runoff velocity, and increasing infiltration and evapo-transpiration. Use of smaller, non-structural BMPs is encouraged. The stormwater management plan should include all practical options to utilize natural areas and landscape features to manage runoff from impervious surfaces.

This curb extension filtration strip helps to improve water quality and aesthetics while also providing traffic calming. Photo Credit: EPA

Watershed Approach – Reduced stormwater volumes or improved water quality can also be accomplished by considering stormwater management efforts upstream and throughout the watershed. By taking a watershed approach, untreated runoff from upstream developments could be affecting the water quality on the project site or downstream from the project area. Treating runoff in areas that predate stormwater regulations (i.e. development built prior to 1982) or in areas suitable for stormwater facility retrofits can provide a net improvement in watershed water quality.

2.3 Soil Considerations

Infiltration Rate – Stormwater soil boring information shows the infiltration rate at facilities proposing wet storage. If infiltration is greater than 0.52 inches per hour, the facility will infiltrate rather than hold water. Either the type of facility should be changed to infiltration or a liner will be required to ensure adequate hydrology for the wet facility.

It is preferable to change the design to accommodate infiltration rather than install liners.

Hydrologic Soil Group (HSG) – Pay attention to facilities that are slated to have permanent water but have A or B HSG soil classifications. Evaluating the HSG in combination with the stormwater boring infiltration rate may lead to the determination that the facility should be infiltration. See discussion above on Infiltration Rate.

Nutrient Soils Testing – Soil tests in addition to the stormwater borings need to be performed at facilities that will require turf establishment or plantings. This test should also determine if any salvageable topsoil exists and the depth to salvage. If topsoil is not salvageable, an item for Furnished Topsoil may need to be added to the contract. Nutrient soil tests should be requested and coordinated through the Landscape Operations Division (LOD).

2.4 Environmental Considerations and Permitting

Stormwater management facilities can cause environmental impacts that require coordination outside of the Highway Hydraulics Division (HHD). The stormwater designer should reduce environmental impacts to the highest extent practical. ***Appendix F*** provides a summary of all environmental permits and approvals necessary on SHA projects. The following describes applicable laws and permitting requirements beyond the typical stormwater management and erosion and sediment control permits.

Environmental Documentation – Environmental documentation is required by the National Environmental Policy Act (NEPA) for projects with Federal funding and by the Maryland Environmental Policy Act (MEPA) for projects with State funding. NEPA and MEPA documentation includes an assessment of all environmental impacts as well as avoidance, minimization and mitigation measures. The NEPA process must be successfully completed before The Federal Highway Administration (FHWA) will approve the release of federal funds. Coordinate with EPLD to confirm that right of way and water quality impacts associated with stormwater management facilities are accounted for in the NEPA and MEPA documentation.

Historic Sites, Parkland, Recreation Sites and Wildlife Refuges - In addition to NEPA and MEPA documentation, Section 4(f) of the 1966 US Department of Transportation Act requires that impacts to parkland, recreational areas, wildlife or waterfowl refuges, or historic sites be avoided unless there is no other feasible and prudent alternative. These lands should be avoided for stormwater management practices. In addition to Section 4(f), Section 106 also governs impacts to historic properties (above and below ground) and requires mitigation and coordination with the Maryland Historic Trust to obtain a Memorandum of

SWM Facilities should be designed so that they do not affect the integrity of a historic site.

Agreement. Coordinate with EPLD to ensure any Section 4(f) and Section 106 considerations are addressed.

Archeology - Stormwater management projects often cross, or coincide with, environmental settings that have a high probability for containing archeological sites. Under MEPA, NEPA, and Section 106, archeological sites are considered a historic property type. Therefore, it is important to recognize that archeological compliance studies would likely be needed to fulfill regulatory requirements, especially for projects that involve large-scale earthmoving activities such as the construction of basins. The purpose of the archaeological studies would be to locate and identify any Maryland/National Register-listed or -eligible archeological sites within the project's archeological Area of Potential Effect (APE), and subsequently analyze project effects on any such sites therein. For most projects, the archeological APE usually coincides with the project's horizontal and vertical limits of disturbance. If study results and interagency project coordination conclude that the project may adversely affect Maryland/National Register-listed or –eligible archeological sites, avoidance options or treatment measures to minimize and/or mitigate adverse project effects would be developed in consultation with the Maryland Historic Trust. For Federally-funded projects, a Memorandum of Agreement (MOA) detailing the stipulations for site avoidance or site treatment would be prepared. Coordinate with EPLD to ensure archeological concerns are addressed.

Wetland, Stream and Floodplain Impacts – Identify impacts to environmental features including jurisdictional wetlands and streams (waters of the U.S.), their buffers, and 100-year floodplains. Evaluate whether impacts are necessary or could be avoided through a different design, facility type, or debiting the water quality bank. Ensure the impacts are accounted for in permit applications. Coordinate with the SHA Environmental Programs Division (EPD) to confirm permitting status.

Forest Conservation - Maryland legislation includes three separate laws pertaining to forest conservation. The Reforestation Law pertains to linear projects that impact over an acre of forest. The Roadside Tree Law pertains to tree impacts totaling less than one acre along a roadside. The Forest Conservation Act pertains to non-linear projects, such as park and ride facilities, stream and wetland mitigation projects, or other site development projects. Coordinate with the SHA Landscape Operations Division (LOD) to confirm that any impacts to trees are accommodated in the requisite tree removal permits.

Chesapeake Bay Critical Areas – Any construction activities within 1,000 feet of the Chesapeake Bay and its tidal tributaries or within 100 feet of tidal water wetlands requires special considerations and mitigation measures. The Critical Areas Commission considers permanent pools of water to be included as impervious land cover. Coordinate with EPLD, EPD and LOD to confirm that Critical Areas requirements are addressed.

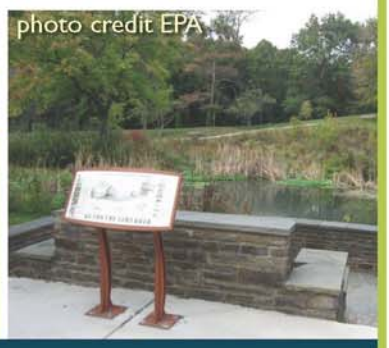
2.5 Water Quality Bank Balance and Maximizing Treated Impervious Surfaces

The HHD maintains an agreement with MDE that allows SHA to obtain credits or debits for water quality requirements on projects. This process is referred to as the water

quality (WQ) bank. Allowances are made to debit the bank when water quality treatment cannot be provided. The option to debit the bank is limited to instances where BMP facility installation is not feasible or will incur environmental impacts. Debits to the WQ bank require HHD and MDE approval.

The SDC reviewer should review instances where the designer is proposing to debit the WQ bank to ensure that the reasons are valid and to verify that the bank balance has not exceeded the maximum debit allowance. The SDC reviewer should also look for opportunities to maximize water quality credits to the water quality bank.

Section 3 - BMP Design



3. BMP Design

The term "Best Management Practices", or BMP, is commonly used to refer to a stormwater management facility. This term infers that the facility is designed in the best possible manner to address stormwater management. Making a facility its "best" requires a balanced and organized design process.

The design process is a means of integrating multiple goals in an organized manner. A stormwater management designer must understand the goals, develop solutions to address the goals, and find resolution when goals compete. The primary goals of stormwater management design are to address environmental sustainability, safety, maintainability and aesthetics. Each of the primary goals can have additional facets specific to the project derived from any of the project considerations. Permit conditions, environmental regulations, and contextual features can have a significant effect on how "best" to design a stormwater management facility.

The design process is not one that can be prescribed because each individual project and site will have its own unique set of issues and constraints that will affect how to address the project's goals. The designer may need to prioritize goals, however, a good design is one that will address all goals.

Principles of organization include harmony, variety, balance, dominance, proportion, movement, and economy. In terms of stormwater management, the organization of design must consider landform, water, hardscape, plantings, and site-specific features that must all work together to create a BMP.

3.1 Landform

Grading Patterns - Contour grading at BMP facilities should incorporate natural shapes with minimal use straight lines or sharp angles. In many instances, geometric or simple shapes appear unnatural and should be avoided. In particular, they become an overly dominant feature that is not in harmony with the surroundings. Landforms should be designed so that they blend seamlessly into the topography. Typically, landform should be characterized by rolling and rounded forms that appear as if they would occur naturally, thus blending with the surrounding landscape.

SWM pond with curvilinear landform creating an attractive landscape feature.

Natural landforms are typically curvilinear with varying widths and gradual transitions. Landforms that are boxy with straight lines and square angles or rounded as a geometric circle or oval are not typically landforms that occur naturally. Furthermore, slopes should gradually change pitch rather than

making sharp transitions. The landform should not appear contrived, forced or unnatural.

Effective design of landform can improve the function and water quality treatment of the BMP. Using curvilinear landforms that incorporate a baffle, or peninsula-like feature, can lengthen the flow path of water in the BMP. Longer flow paths allow more time for sediment to settle out of the water. See *Figure 3-1* for examples of curvilinear and natural shapes and *Figure 3-2* for examples of geometric shapes to avoid.

Figure 3-1. Curvilinear and Natural BMP Shapes

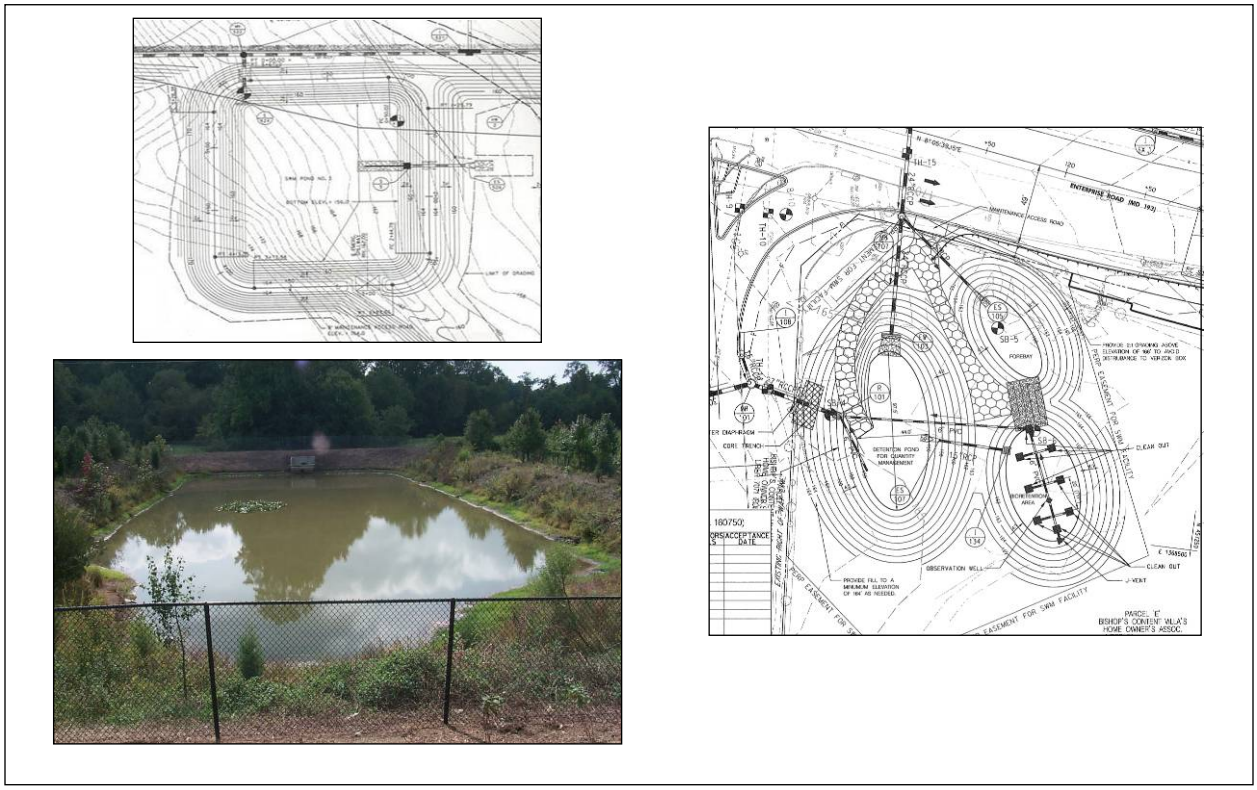


Figure 3-2. Simple and Geometric Shapes to be Avoided

Baffles and Peninsulas – Baffles should be constructed by leaving the baffle material in situ of undisturbed virgin soil, and should not be constructed from fill material. Creating baffles from fill material will result in easily eroded baffles that are ineffective at directing flow after several seasons (see *Figure 3-3*). To ensure the contractor leaves the baffle material in place rather than removing it to simplify the grading operation and placing back unconsolidated fill material or common borrow, the minimum width for a baffle landform should be 20 feet. For smaller facilities, it should be proportional to the overall size of the basin being no less than a quarter of the total width of the facility.

Baffle Constructed In Situ Holds Form Over Time

Baffle Constructed from Fill

Baffle Constructed from fill after one year

Figure 3-3. Examples of Baffles (Good and To-Be-Avoided)

Landform Features to Avoid - Landform can also facilitate maintainability. Steep slopes and tight angles are difficult for maintenance crews to navigate. Islands should also be avoided because they are not accessible to maintenance crews.

Establishing Right of Way - Landform grading should be considered and provided at the concept development stage. The preliminary grading plans should be developed reflecting the desired landform. This will ensure that enough right-of-way is programmed into the budget to ensure this type of landform is possible in the final design (see *Figure 3-4*).

The right of way should be set at least 15' beyond the toe of an embankment slope. This area is part of the critical woody-free zone that must be maintained by SHA.

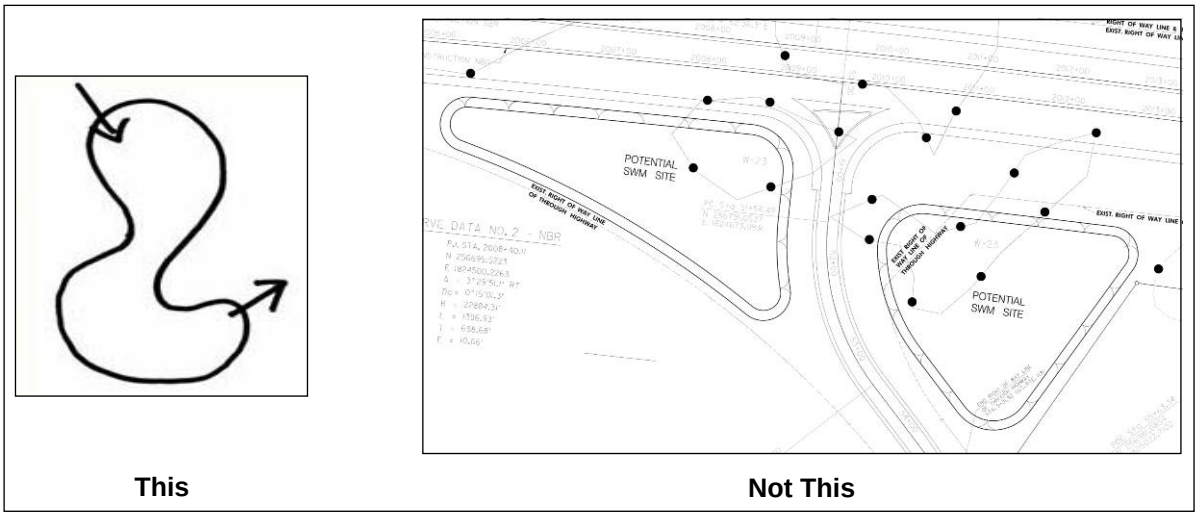


Figure 3-4. Concept Stage Should Reflect Natural Shape

3.2 Slope

Slope – The slopes within a BMP that encompass the frequently fluctuating zone (area between the permanent water surface and the 10-year water surface elevation) require special consideration. This area is prone to erosion due to the frequently fluctuating water surface elevation and the tendency of the applied seed to float. To improve the sustainability of these slopes, they should be graded at 4:1 or flatter and should include a combination of seed and herbaceous plantings.

Grade steepness should be dictated by safety and mowability. Maximum steepness is restricted to 4:1 or flatter in certain circumstances as defined in the following sections.

Grading for Mowability - Grading design should facilitate mowing in areas require routine mowing. Areas that require routine mowing are outlined in *Table 3-1*, and should be 4:1 or flatter in steepness. Access should be provided to all mowing areas from the maintenance access. Dimensions and turning requirements of standard mowing equipment shall also be considered in the design.

Table 3-1. Areas Requiring Routine Mowing

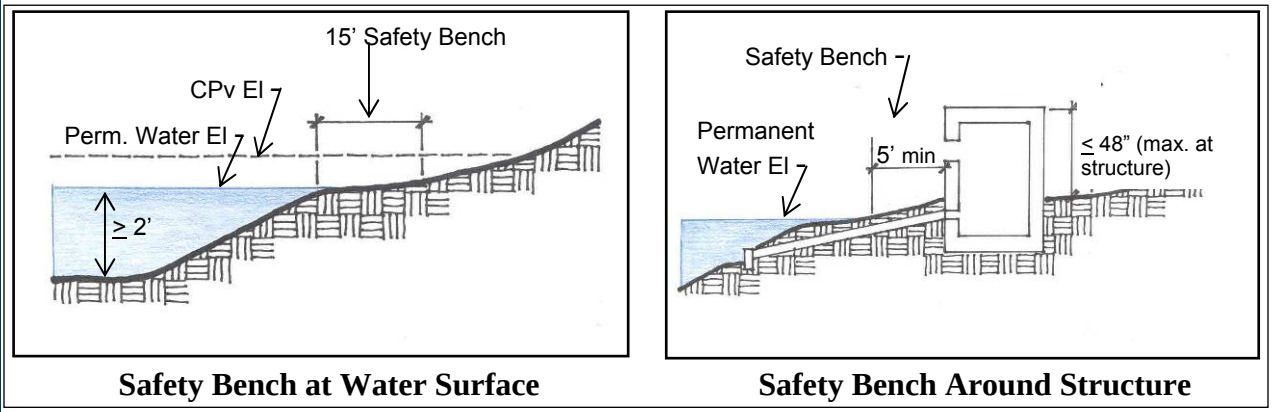
1. Maintenance Access
2. Code 378 SWM Free-Standing and Roadway SWM Embankment (both upstream and downstream faces)
3. 15 ft. Clear Zone at Code 378 SWM Embankment Toe
4. 25 ft. Clear Zone Around SWM outfall structure
5. Emergency Spillway
6. Bottom and Side Slopes of Dry Swales and Surface Sand Filters
7. Filter Strips at Grass Channels, Infiltration Basins, Infiltration Trenches, Dry Swales and Bioretention Areas

Safety Grading Requirements - SHA policy requires that safety features be provided in SWM facilities in lieu of fencing or railings wherever possible. Safety features can include landform, signs or plantings. Facilities with 2 ft. deep permanent water or deeper (including forebays) require safety grading. Safety grading features include:

- Side Slopes should be 4:1 or flatter. This includes both stand-alone Code 378 SWM embankments and roadway Code 378 SWM embankments. Cut slopes with reforestation plantings can be steeper than 4:1 with SHA approval.

- Benches should be placed around the perimeter of permanent pools that are 2 ft. deep or deeper. The benches should be a minimum 15 ft. wide and centered at the permanent pool elevation with a grade of 12:1 or flatter. (See *Figure 3-5*.)

- MDE requires that a safety railing be placed at endwalls and outfall structures that are 48 in. or greater in height (page 3.15 of the *2009 Maryland Stormwater Design Manual*). SHA policy requires that SWM outfall structures be designed so that they do not exceed this height in order to eliminate the need for railings. This can be accomplished by grading a bench around the structure. This bench should extend a minimum of 5 ft. beyond the structure on all sides. (See *Figure 3-5*.)



Safety Bench at Water Surface **Safety Bench Around Structure**

Figure 3-5. Safety Benches

- Signs can also be used that state "No Trespassing State Highway Administration", from the Maryland Standard Sign Book, Standard No. R11-2(4).

Requirements for Fencing Approval - If safety grading is not feasible for the facility or outfall structure, the designer must demonstrate this to the Division Chief of HHD using grading studies, sketches, computations or other means as appropriate. Fencing at stormwater management facilities can only be used as a last resort and written approval must be obtained from the HHD Division Chief before proceeding with fence design and specification. The form to request fencing approval is in ***Appendix G*** and should be filled out and submitted to HHD for signature. Please see *Section 5 - Fences and Railings*, for more information.

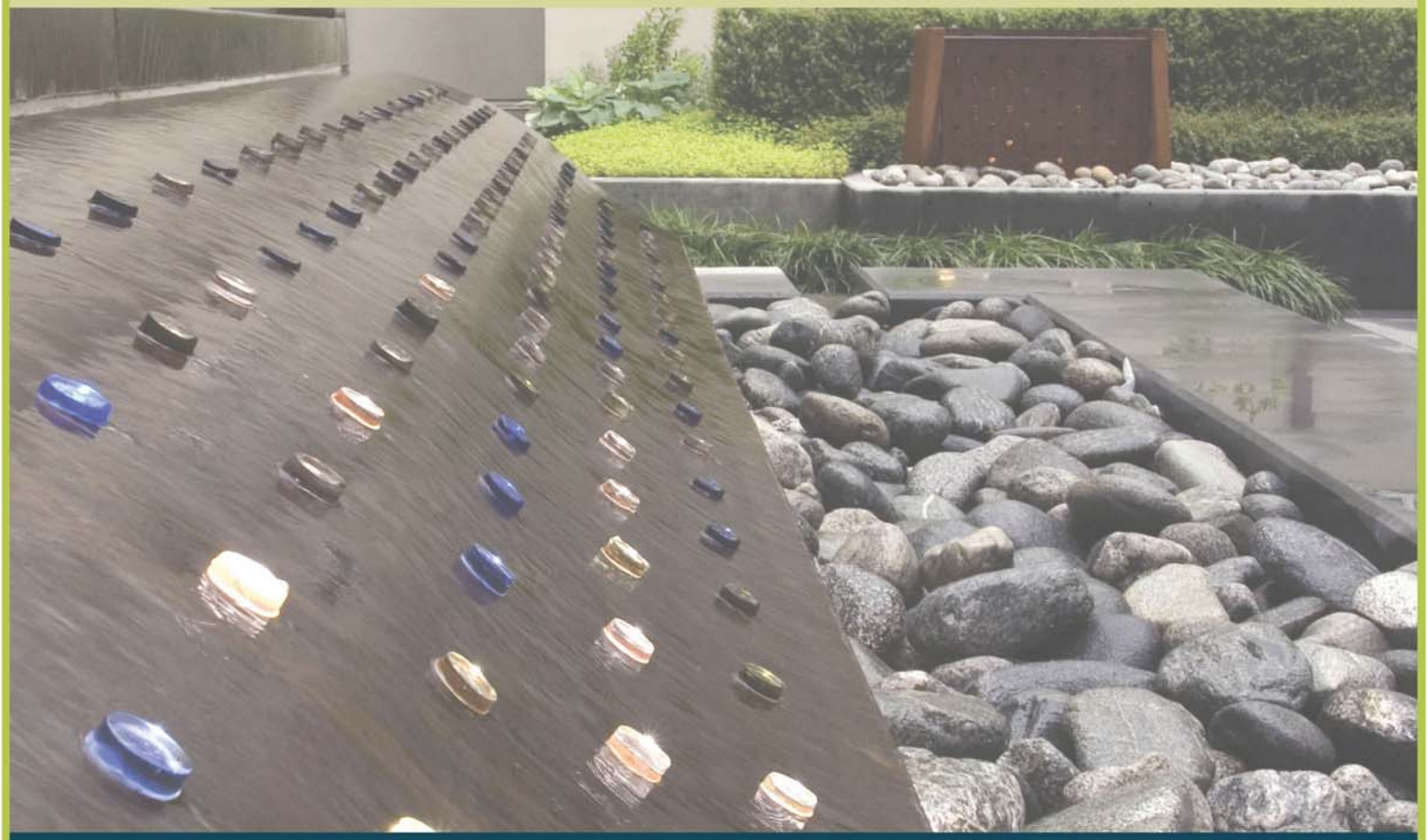
3.3 Summary

Preferred Landform Patterns:

- Use curvilinear and natural landform shapes.
- Use gradual changes in slope.
- Use flatter slopes when possible to reduce risk of erosion.
- Blend into surrounding topographic landscape.
- Use safety grading features including flatter slopes and benches.
- Use baffles and peninsulas to lengthen flow paths and residence time.

Landform shapes to be avoided:

- Geometric or simple shapes, such as ovals, ellipses or pure circles in the wrong context or treatment.
- Steep slopes.
- Islands because they are difficult to access for maintenance purposes.



Section 4 - Stormwater Management Structures




4. Stormwater Management Structures

Outfall riser structures, weirs, end walls and head walls can each serve as an important functional item in a BMP, but have potential to be visually obtrusive. These structures should be designed to blend into the surroundings. In some contexts, the structure may be designed as an architectural feature and in others, it may be designed so that it is less visible. The structures should not present any safety hazards and should be designed to facilitate maintenance.

4.1 Safety Features at Stormwater Management Structures

Outfall Riser Structure Top Dimension – Maintenance crews often need to stand on top of the structure to access the inside and perform routine maintenance. When a structure is over 30" tall, the top dimension should include a minimum 4'-2" space on two consecutive sides adjacent to the manhole cover. This will allow room for a maintenance worker or inspector to safely maneuver the manhole cover from the frame. (See *Figure 4-1*.)

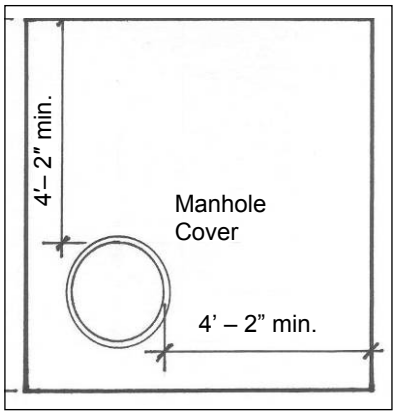
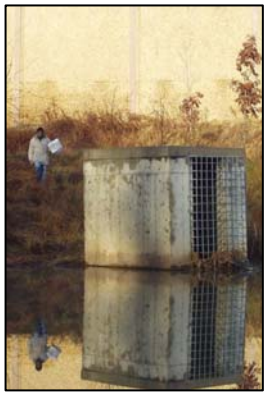


Figure 4-1. Plan at Riser Structure

Height – All outfall structures should be less than 48" in height. Safety grading should be provided around the SWM outfall structures and endwalls. Safety grading, as discussed in *Section 3.2.*, can also be used to reduce the overall height of the structure.

Ladder rungs should also be provided on the outside of the riser structure if it is greater than 30" high.



This riser does not meet safety criteria because of its excessive height.

4.2 Structure Aesthetics

The structure design should be appropriate and attractive. The structure design should include appropriate details that show design elements such as appropriate. These may include:

- Concrete integral coloring concrete to provide a softer structure color tone.
- Use of formline finishes to create a more attractive finish.
- Use of chamfers to soften structure edges and reduce potential for chipping.
- Epoxy coatings or paint for metal components.

Concrete Color - Where concrete stormwater management outfall structures are visible from the roadway and/or adjacent visually-sensitive land uses, the use of integral color pigment in the concrete mix is recommended. The color shall meet Federal Standard 595B and shall be chosen from the following choices: 30277, 31219, and 30145. Concrete staining is not preferred.

Grates - There should be no flat grates on top of the outfall structure. If modified inlet structures are used at bioretention facilities and sand filters, the inlet grate should be modified so it is not flat or has ability to bypass flow if the grate become clogged.

Trash Racks - Trash racks should be provided and should not be flat on the top. Trash racks should be, at a minimum, galvanized, but may also be painted or epoxy-coated black.

Low Flow Device – Low flow device placement and type should be appropriate. The use of submerged devices is preferable (see *Figure 4-2*).

The low flow device is visible above the water surface and is unattractive

Woody vegetation, including ivy, must be kept clear from a riser structure to ensure proper function.

Low Flow Device uses a T-Connection and Runs Parallel to the Side Slopes

Visually Obtrusive Low Flow Device

Figure 4-2. Low Flow Device Can be Unobtrusive

Section 5 - Fencing and Railings




5. Fences and Railings

5.1 Fence Approval

The use of fences to enclose SWM facilities should be avoided whenever possible so that the facility is accessible for future maintenance activities. Safety grading features discussed in *Section 3.2* alleviate the need for fencing. However, if the facility faces considerable restrictions that make Safety Grading impossible, the facility designer may request approval from the HHD Division Chief to use fencing. This approval will only be granted if the designer can prove that safety grading features are impossible to accommodate. This can be done using grading studies, sketched grading plans, computations, or other means as appropriate. Should the designer seek approval for use of fencing, the Fencing Approval Form should be submitted along with any documents to prove that safety grading is not possible. This form can be found in ***Appendix G***.

When fences are used, they should be sited so as to blend into the surroundings as much as possible.

5.2 Fence Requirements and Design

When fencing is required and allowed, it should be designed according to the following criteria. Please note, these requirements and criteria do not apply to SHA right-of-way fencing.

- 42-inch height maximum.
- Black or brown coated vinyl chain link fencing with top rail.
- Since the top rail of the chain link fence can be a spearing hazard if a vehicle were to run into the fence, the top rail should be eliminated and the standard SHA fence with tension wire at top and bottom should be used instead (see *Figure 5-1*). See *Section 7 – Safety Considerations* for discussion on roadside safety at stormwater management facilities.

Black Vinyl Coated Chain Link Fence with Top Rail

Black Vinyl Coated with Tension Wire

Figure 5-1. Chain Link Fence Options

- Decorative fencing, when site is highly visible, warrants the added expense. The same color choice and detailing should be used throughout the project.

Examples of ornamental fencing used for SWM facilities.

- A 12 ft. wide double gate should be provided where fencing is used at the stabilized maintenance access. A method to secure the gate in the closed position should be included in the design detailing and an exterior grade padlock with 2 keys should be provided to SHA (one each for HHD and maintenance) for each gate.
- Visually unobtrusive placement that would typically follow along a contour line or other significant land feature (see *Figure 5-2* and *Figure 5-3*).

Fence Steps Up and Down Contours (Avoid)

Fence Follows Contours (Preferred)

Figure 5-2. Fencing Should Follow Contours

5.3 Temporary Fencing

Temporary fencing is a requirement for sediment basins during the construction process and should be detailed on the approved Erosion and Sediment Control plan. If temporary fencing is used, provision should also be made to secure it against high winds and unauthorized relocation (see *Figure 5-4*).

Figure 5-3. Additional Fencing Guidance at Weirs and Ditches

5.4 Verify Railing Requirements and Design at Hydraulic Structures

Safety should be considered in the design of hydraulic structures such as headwalls and end walls. Railings should be provided at endwalls and headwalls that are 48 inches or greater in height from the ground surface (including submerged ground surface) and should be designed according to the following criteria (see *Figure 5-5*). The SHA Office of Bridge Design has fencing standards for structures:

- 42 inch height.
- Black or brown vinyl coated chain link with top rail (see *Figure 5-1*).

Figure 5-4. Footer at Temporary Fencing

Figure 5-5. Chain Link Railing at Endwall

5.5 Summary

Preferred Fencing, when approved by the HHD Division Chief:

- 42” Height
- Black or brown coated vinyl chain link or decorative fencing
- Top rail, unless within a clear zone
- Follows along contour lines
- With a 12’ gate that matches the fence

Section 6 - Maintenance Access




6. Maintenance Access

Maintenance is an important aspect of the continued functionality and appearance of a stormwater facility. A stabilized maintenance access from a public right-of-way to all SWM facilities should be provided.

6.1 Placement

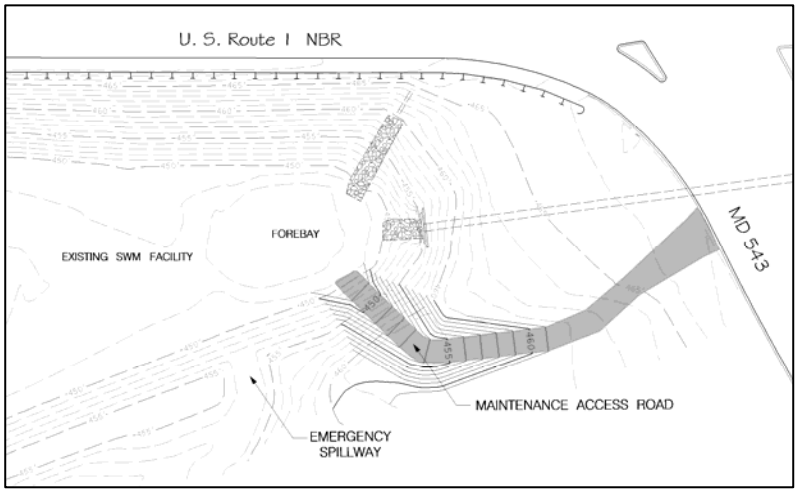
The placement of the maintenance access should be considered at the beginning stages of the facility's design. This will help ensure that the maintenance access is accommodated and properly designed. The following includes a list if placement requirements:

- The maintenance access should connect to a public road where maintenance trucks can pull off.
- The entrance to the maintenance access should be unobstructed. Please see *Figure 6-1* for examples of how maintenance access drives have been obstructed, rendering them useless. Common obstructions include traffic barrier, traffic signs, vertical curb, parked cars, and woody vegetation.

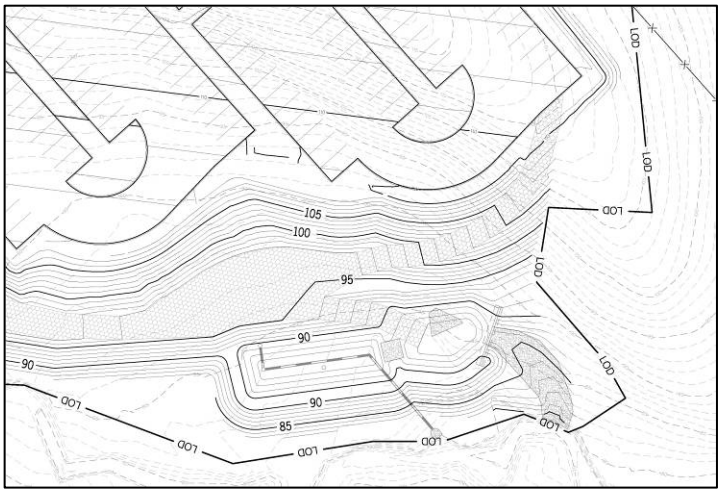
Obstacles blocking the maintenance access gate render the access useless.

Figure 6-1. Obstructed Maintenance Access

- The access road should connect to the forebay, inflow, and outflow structures.
- When possible, space should be provided at the beginning and end of the access to allow large maintenance vehicles to turn completely around. Room should be provided at the entrance for a maintenance truck with trailer to pull completely off the roadway without blocking the maintenance access.
- The surface of the maintenance access road should be a minimum of 1 ft. above any permanent water surface.
- The access should be graded into the landforms by benching into side slopes somewhat parallel to contours rather than ramping down side slopes perpendicular to the contours. Benching reduces erosion by breaking runoff travel path at slopes and is also more visually appealing. (See *Figure 6-2*.)



Access Road Ramped (Avoid) into side slope that encourages runoff to flow down road causing erosion



Access Road Benched (Preferred) into Side Slope so Runoff sheets down slope and not down road

Figure 6-2. Benched vs. Ramped Access Roads

6.2 Design Requirements and Detailing

To safely accommodate typical maintenance vehicles, the maintenance access design must follow the following criteria:

- A Preferred minimum width of 12 ft should be provided. A 10 ft. width may be acceptable only when limited right-of-way, environmental impacts, or other factors require.
- The maintenance access should be constructed with a 6 in. depth cellular confinement system filled with open graded aggregate, topped with 4 inches of topsoil and seeded and mulched. See *Figure 6.3* for an example construction detail of the cellular confinement system.
- The preferred maximum slope at maintenance access is 8:1 (12%). Slopes as steep as 6.6:1 (15%) may be used in extreme conditions, but is not preferable.
- The preferred cross slope for benched access road is 2%.

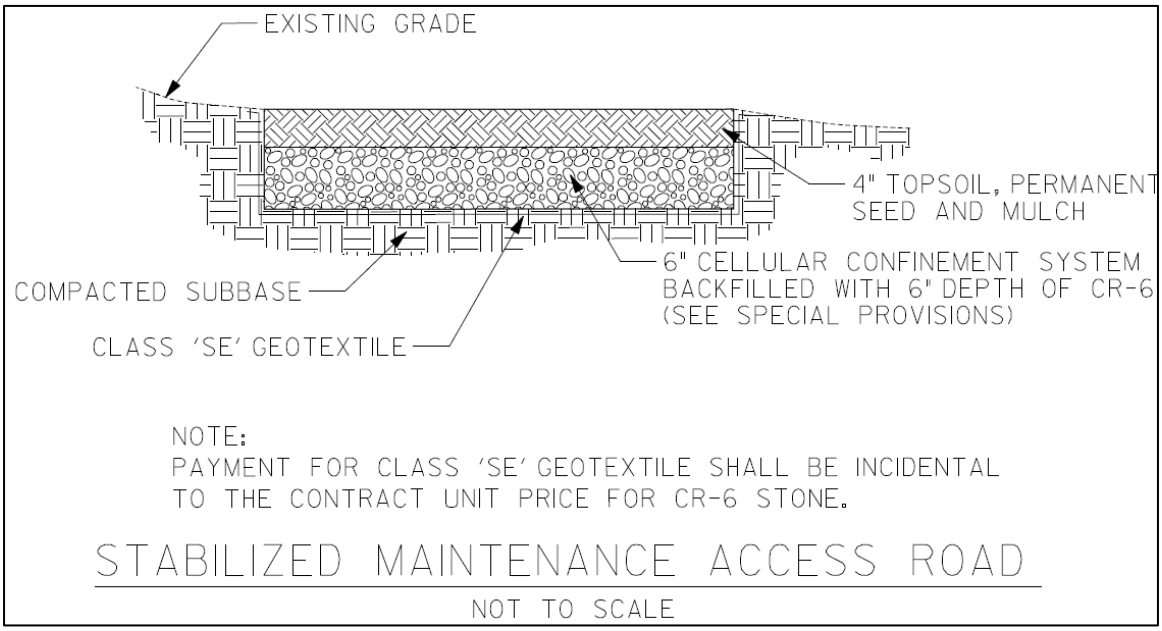


Figure 6-3. Construction Detail of the Cellular Confinement System

- Maintenance access drives should be designed to follow along contours or a slope bench rather than as a ramp or swale within a slope. A ramped maintenance access concentrates water flow and encourages erosion as runoff along the ramp, and this type of design will require additional stabilization. The maintenance access that is 'benched' into the slope with a cross slope will slow runoff flowing down the side slopes without channeling it along the ramp. The benched access road is preferred. See *Figure 6-2* for examples of ramped verses benched access drives.
- The maintenance access drive should include a turn-around space to allow maintenance vehicles to turn around before exiting the area. *Figures 6-4*, *6-5* and *6-6* show examples of turn around designs that can be incorporated with a maintenance access drive.
- The maintenance access drive should include a three foot clearance area without any barriers that would prohibit opening vehicle doors when parked on the access drive. Potential barriers would include hedgerows, guide rails, fences, sound barriers, etc.

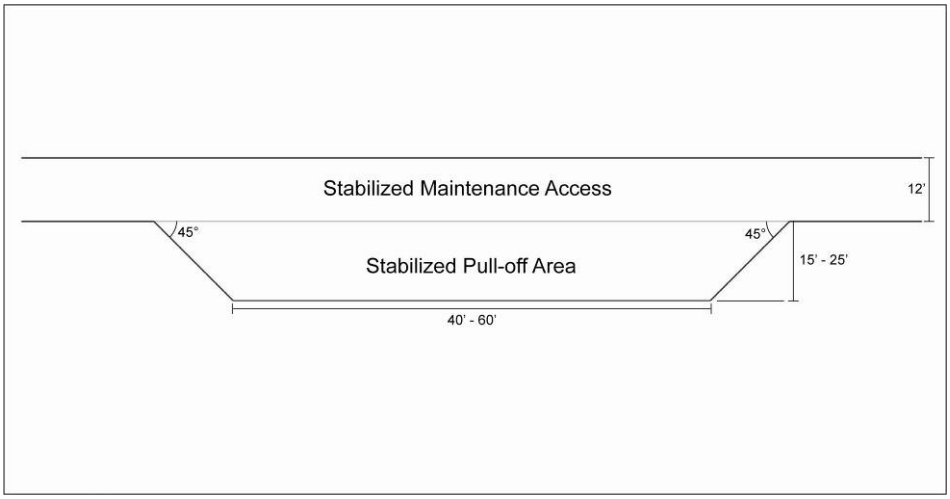


Figure 6-4. Pull-Off Area Dimensions for Maintenance Vehicles

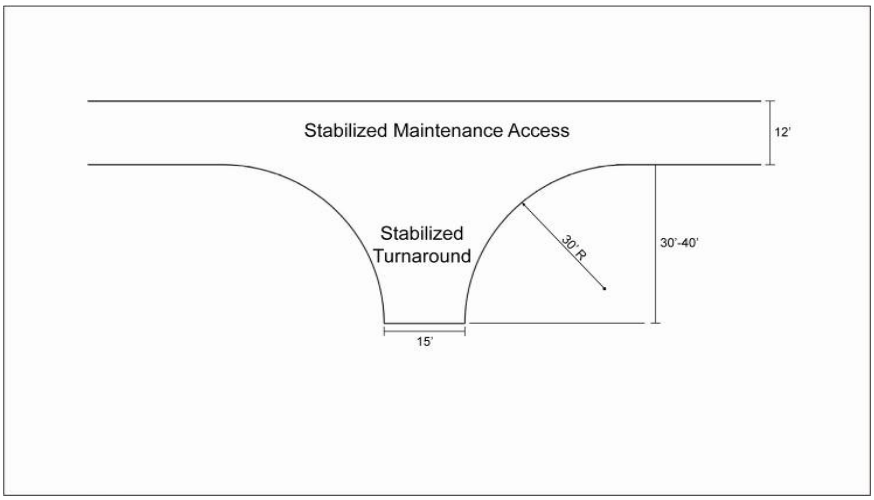


Figure 6-5.Turnaround Dimensions for Maintenance Vehicles

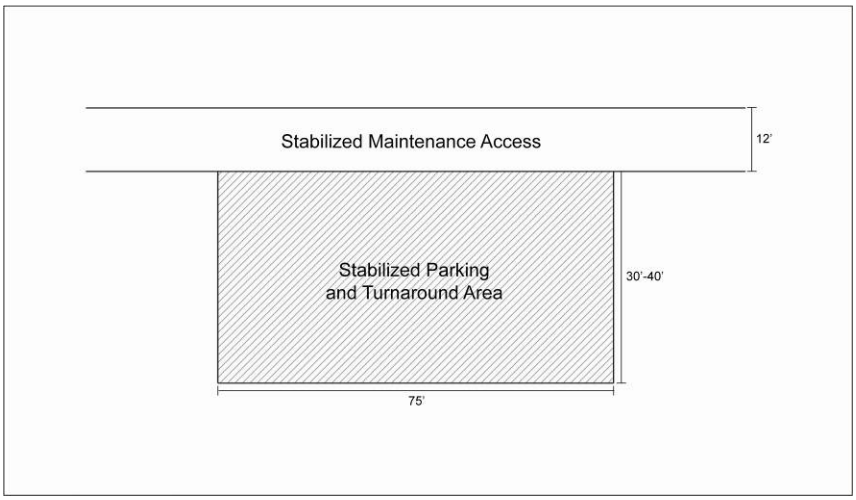


Figure 6-6. Combination Parking Area and Turnaround Dimensions for Maintenance Vehicles

6.3 Entrance Requirements

Pull off – Access should be provided from a public roadway right-of-way (see *Figure 6-2*). If the roadway is a high speed, limited access facility, consideration should be given to the safety of maintenance vehicles, including trailers and other necessary equipment for slowing and pulling off the roadway. For instance, a widened, stabilized shoulder may be needed. Consider both entering and exiting the facility when reviewing the facility design for this requirement.

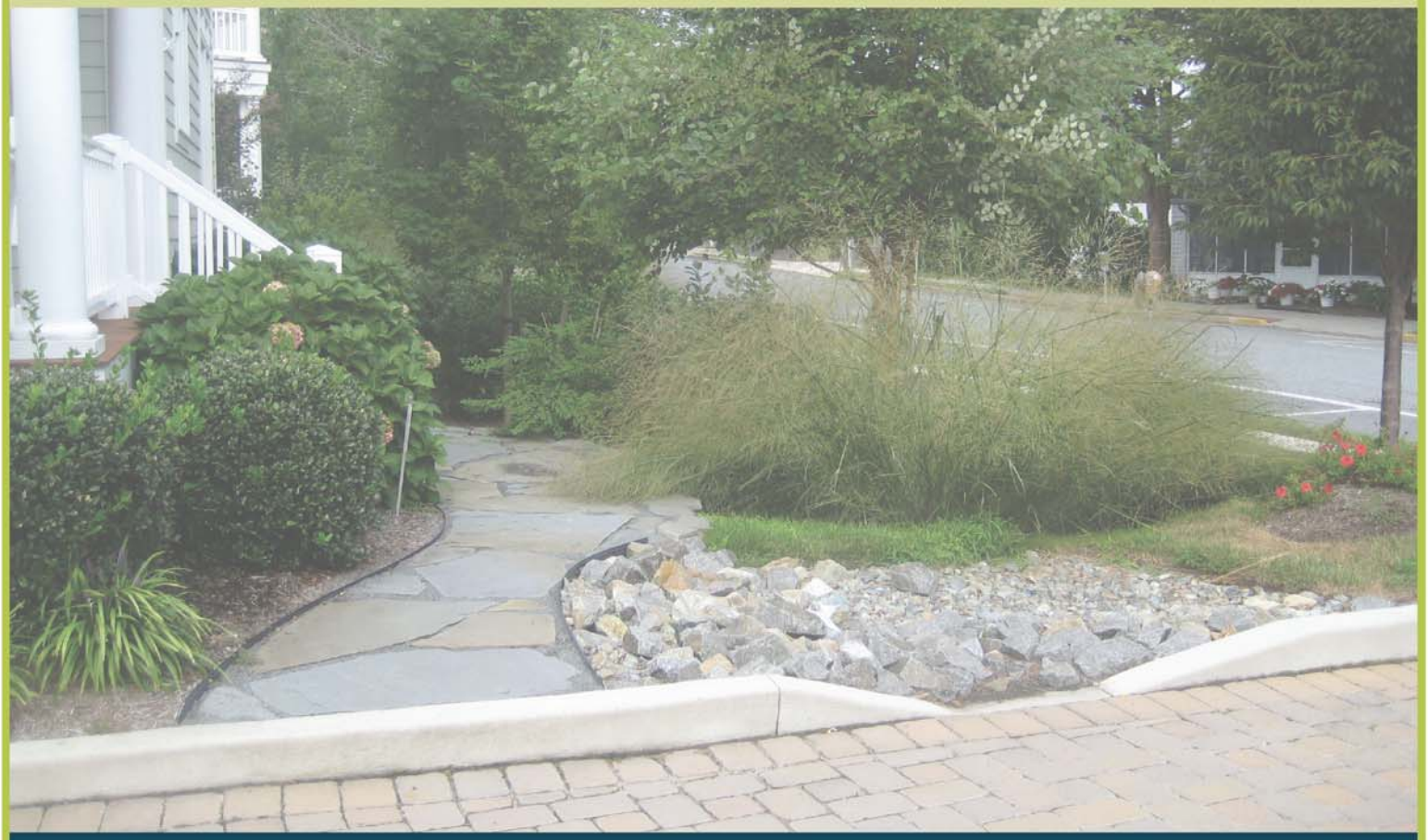
Concrete Apron/Depressed Curb – If the roadway is closed section with curb and gutter, a concrete apron should be provided with depressed curb (See *Figure 6-7*). A depressed curb alone may be acceptable at SWM facilities when speeds of 10 mph can be obtained.

Figure 6-7. Concrete Apron and Depressed Curb Provided at Maintenance Access

Unobstructed – The entrance should not be blocked with a traffic barrier, parking or other permanent obstructions.

Turning Radius – A turning radius should be included at the maintenance access entrance to accommodate turning vehicles from the main line.

Barrier Placement – If a traffic barrier is used along the roadway, an opening should be provided to accommodate the maintenance access entrance. End treatments and opening configurations at traffic barrier should adhere to the *AASHTO Roadside Design Guide, 3rd Edition* and SHA *Guidelines for Traffic Barrier Placement and End Treatment Design*.



Section 7 - Traffic Safety

7. Safety Considerations

Oftentimes, SHA's stormwater management facilities are located along roadways. Safety considerations are of paramount importance, especially in the public right of way.

7.1 Traffic Barriers

The need for traffic barriers should be evaluated using the *AASHTO Roadside Design Guide, 3rd Edition* and SHA *Guidelines for Traffic Barrier Placement and End Treatment Design*. Factors that can affect the roadside safety in stormwater management design are based upon the placement of a facility within the clear zone, placement of outfall structures and embankments, steep slopes and deep permanent water. The use of traffic barrier may be warranted and, if so, it should be included in the roadway plans.

If a traffic barrier is used along the roadway, an opening should be provided to accommodate the maintenance access entrance. End treatments and opening configurations at traffic barrier should be provided and adhere to the design requirements outlined in the guidance mentioned above.

Be aware that the top rail at the chain link fence can be a spearing hazard if a vehicle were to run into the fence. So if the fence is placed in a location where this may be the case, such as just outside the clear zone, then the top rail should be eliminated and the standard SHA fence with tension wire at top and bottom should be used instead.

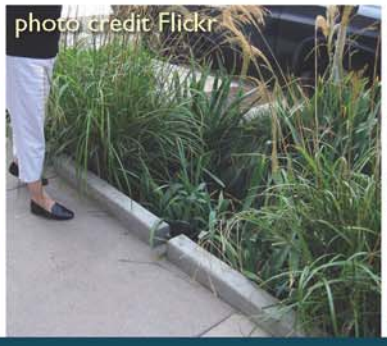
7.2 Clear Zone

The facility plan should accommodate clear zones along the roadway. Clear Zones are areas where obstructions along the roadside present a safety hazard for errant vehicles. Clear Zone distances vary depending on the road type and vehicle speeds. Roadsides with curb or traffic barrier railings have a reduced clear zone. Please refer to the *AASHTO Policy on Geometric Design of Highways and Streets* for more information.

7.3. Sight Distance

The facility plan should accommodate all necessary sight distance requirements for safety. Unobstructed sight lines are necessary for vehicular turning movements at intersections, ramps, driveways, and maintenance access drives. Plant material, fences, signs, guide rail and other visual obstructions can cause safety hazards. A sight triangle should be considered as area without visual obstructions. Objects should be less than 2' tall within sight distance triangles. Tree canopies and signage should be at least 7' above ground, depending on topographic features, with careful placement of poles and trunks to reduce sight distance blockages. Sight distance calculations vary depending on the road type and vehicle speeds. Please refer to the *AASHTO Policy on Geometric Design of Highways and Streets* for more information on sight distance stopping requirements.

Section 8 - Planting



8. Planting

Plantings can provide visual enhancement to stormwater facilities, but offer other important benefits as well. Plants provide nutrient removal, particulate pollutant removal, shade, wildlife habitat, and natural heritage continuation. Plantings are also important for maintaining or building green infrastructure hubs and corridors, which are undeveloped lands most critical to Maryland's long-term ecological health. Hubs are typically unfragmented areas, hundreds or thousands of acres in size, while corridors are linear remnants of natural lands such as stream valleys and mountain ridges. Stormwater management facilities are oftentimes located in or adjacent to green infrastructure hubs and corridors and help expand the green infrastructure network.

It is important to utilize native vegetation when selecting plants for a site. This avoids the accidental introduction of invasive species, ensures greater likelihood of plant survival and adaptability, and allows the facility to merge into the adjacent landscape.

Plantings should take on a natural appearance. Groups of a single species should be placed in loose drifts interspersed with individual plants of different species to improve visual quality.

8.1 Woody Plant Restrictions and Buffer Zones

Planting of woody species, including live fascines, should adhere to Pond Code 378 restrictions at SWM embankments and SWM outfall structures. The following should also apply:

- No woody material shall be planted on the SWM embankment (roadway and non-roadway), within 15 feet of the toe of SWM embankment fill or within 25 feet of the SWM outfall structure. This woody free area should be labeled on the plan sheets.
- A 15-foot buffer zone within SHA right-of-way should be provided at the toe of Code 378 SWM embankments (roadway and non-roadway) that should be maintained free of woody vegetation (see *Figure 8-1*). Herbaceous vegetation needs to be maintained at 10 in. height or less.

Example of stormwater facility with trees planted along the embankment. This can cause damage to the embankment and ultimately cause embankment failure.

8.2 Plantings within Airport Zones

Plantings within Airport Zoning Districts should be in compliance with the most recent Maryland Aviation Administration requirements. Generally speaking, MAA and FAA regulations require that stormwater management facilities within a five mile radius of a

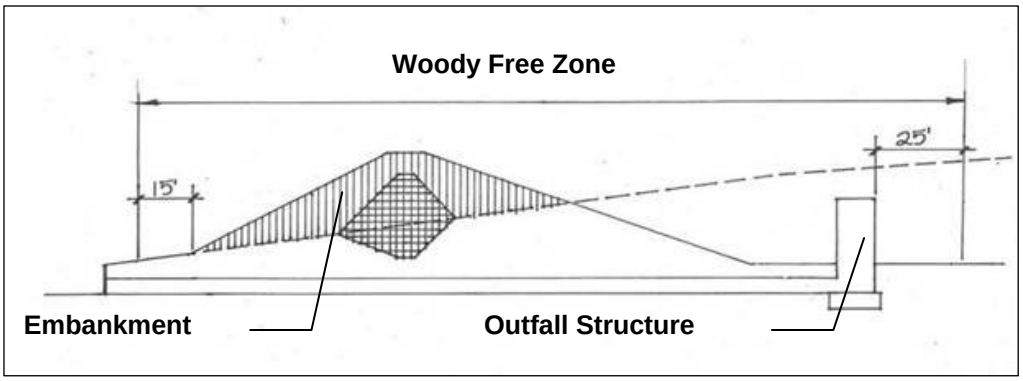


Figure 8-1. Woody Plant Restriction Area at Code 378 SWM Embankment

airport be planted with vegetation that has low-wildlife value. (Refer also to *Section 2 – Stormwater Management Considerations* regarding airport planting restrictions.)

8.3 Soil Amendments (Fertilizer, Lime, Compost, Mulch)

Soil tests should be performed at the stormwater management facility site during design to determine the need to provide additional additives to the soil, determine if there are any toxic components to the existing soils, and to determine where there is adequate topsoil to be salvaged and how much.

Soil amendments should be applied as required according to soil testing to achieve healthy growth of plants and seed areas to ensure establishment. This includes turf establishment and plant pit amendments. Nutrient Management Plans shall be obtained from Landscape Operations Division (LOD) prior to application of soil amendments.

Areas targeted for warm season grass and native meadow establishment should not be amended with fertilization and other amendments.

Mulch beds (shredded hardwood bark mulch or straw mulch) should not be used in SWM facilities below the 10 year flood line, except for Bioretention facilities. The mulch can float and clog orifices/openings.

8.4 Planting Requirements

The design should provide planting according to the suggested planting for each zone that is required by the facility. *Tables 8-1* and *8-2* on the following pages list the possible planting zones and requirements for planting at different facility types. *Figure 8-2* graphically depicts the various planting zones.

Ponds will have aquatic benches that are Emergent & Floating Aquatic Zones; water depths greater than 4 ft. that are submerged aquatic zones; and storm elevations for up to the 10-year storm that are frequently fluctuating zones.

Wetlands will have micro-pools or deep pools that are submerged aquatic zones, shallow wetland areas that are Emergent & Floating Aquatic Zones and water fluctuations up to the 10-year storm that are frequently fluctuating zones.

Table 8-1. Recommended Minimum Planting Requirements at SWM Ponds and Wetland Hydrologic Zones

Quantity/ Placement Considerations	Min. Size/Rate	Root Condition
Submerged Aquatic Zone (4 ft. or greater depth permanent water)		
• 1 plant per 9 cu. ft. of water volume for water depths 4 ft. or deeper. • Min. 2 species with no one species being greater than 60% of the total plants	8 in. ht./length	Bare root
Emergent & Floating Aquatic Zone (up to 18 in. depth permanent water)		
• 24 in. centers max. spacing (2.9 plants per 10 sq. ft.) • Min. 3 species shall be provided with no one species being greater than 50% of the total plants in this zone • Min. 30% of the species shall be broadleaved or floating leaved	#1	Container grown (minimum #SP4 quart size)
Frequently Fluctuating Zone(permanent water surface to 10-year water storm elev.) and Facilities without a Permanent Pool		
Live Fascines or Wattles (optional) • 3 species in each fascine bundle • Place parallel to contours • Min. one layer of fascines at water's edge • Do not use when facility is lined	4 in. diameter by 6 ft. length	Bound bundles
Plug Planting • Min. 3 species of plugs shall be provided with no one species being greater than 50% of the total plants in this zone • Plugs shall be spaced at max. 24 in. centers (2.9 plants per 10 sq. ft.) • Seed should also be placed in areas with plug plantings.	2.25 x 5" deep	Container grown
Seed and Mulch • Shall be included to provide permanent stabilization and include SWM Seed Mix along with SHA Special Purpose Mix • Mulch shall be according to SSCM 2008, Section 705.03.09. • No straw mulch shall be used at SWM facilities. Wood cellulose fiber mulch is to be used. • Over seeding of existing vegetation is to provided if good groundcover is not present after the Plant Establishment Phase (1 year)	16 lbs./ac. For SWM Seed Mix 10 lbs/ac. For Special Purpose Mix	
Perimeter Shade Planting (emergent & floating aquatic zone to 10 yr. water storm elev.)		
Deciduous Canopy Trees • 1 tree if areas is ≤ 4,000 SF (measured at 10 YR water surface contour line) • 3 trees if (4,000 SF < area ≤ 8,000 SF) • 5 trees if (8,000 SF < area ≤12,000 SF) • If area > 12,000 SF, add 1 additional tree for each additional 4,000 SF • If facility is lined, no trees or woody shrubs allowed within limits of liner	2 in. cal. (smaller stock may be utilized on steep slopes)	B & B (Container grown stock is acceptable for trees up to 1.5 in. cal.)
Evergreen Trees/Needle-Leaved Conifers	6 ft. height	B & B

Table 8-1. Recommended Minimum Planting Requirements at SWM Ponds and Wetland Hydrologic Zones

Quantity/ Placement Considerations	Min. Size/Rate	Root Condition
Understory or Ornamental Trees • 2 if area is ≤ 4,000 SF, add 1 additional tree for each additional 1,000 SF • Multiple stemmed trees shall have a min. of 3 trunks.	1 ¾ in. cal. If single stemmed 5 ft. ht. if multi-stemmed	B & B
Woody Shrubs 5 for every understory or flowering tree required	24 in. ht. or spread	Container Grown (#3 Min)
Planting Bed Preparation • Planting beds shall not be used at SWM facilities below the 10 YR water surface elevation. Instead, individual plants shall be installed in plant pits that are not mulched. • Areas between planting pits shall be stabilized with seed and mulch		
Seed and Mulch See Frequently Fluctuating Zone seed and mulch requirements.		

Table 8-2. Recommended Minimum Planting Requirements for SWM Filtering Practices (organic filter, dry swales)

Quantity/ Placement Considerations	Min. Size/Rate	Root Condition
Organic Filter		
Sod • Flow shall be diverted from filter practices until 2 in. ht. of permanent turf stabilization has been established • In cases where flow cannot be diverted, sod shall be applied to the filter surface	Section 708 Section 920 (SSCM 2008)	
Seed and Mulch • SWM Seed Mix • Special Purpose Mix • No straw mulch shall be used at SWM facilities.	8 lbs / ac. 10 lbs / ac.	
Bioretention		
Trees • Min. 0.76 trees per 100 SF (filter surface area measurement) • Substitution of (2) Understory/ornamental trees (1.5" cal. single stem or 5' height multistem) per each (1) deciduous canopy tree is permitted where site constraints preclude use of canopy trees. • Filter medium depth ≥ 5 ft. • If the facility has underdrains or is lined, large canopy trees should not be placed directly in the bioretention facility. Instead, they should be placed adjacent to the facility to provide shade to understory plants. In this case, plant large trees 5 feet away from the perimeter of the filter medium/underdrains or liner. • No straw mulch should be used at SWM facilities.	2 inch cal.	B&B
Shrubs	24 in. ht. or	Container

Table 8-2. Recommended Minimum Planting Requirements for SWM Filtering Practices (organic filter, dry swales)

Quantity/ Placement Considerations	Min. Size/Rate	Root Condition
Organic Filter		
• Min. 2.8 shrubs per 100 SF (filter surface area measurement) • Filter medium ≥ 2.5 ft.	spread	Grown (#3 Min)
Herbaceous layer • 3 perennials or grasses can be substituted for 1 required shrub • No more than 50% of all plants shall be perennial or grasses	#1 container	Container Grown
Mulch • 3 in. depth shredded hardwood mulch, evenly distributed and raked smooth	Section 920 (SSCM 2008)	

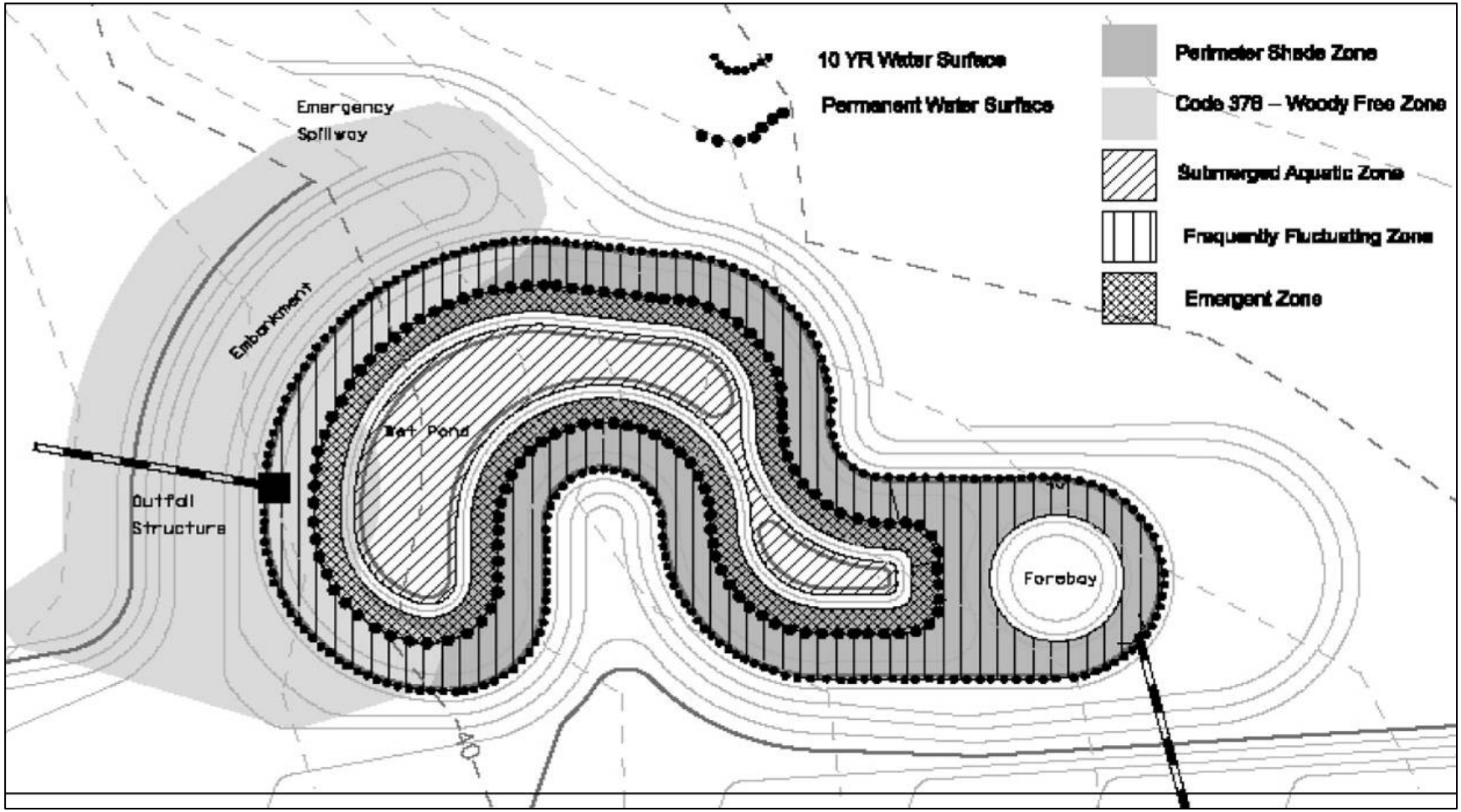


Figure 8-2 Stormwater Management Planting Zones

Perimeter Shade Plantings - Both SWM ponds and wetlands are required to have the perimeter shade planting, which covers the emergent zone through the frequently fluctuating zone. However, woody shade plantings should not be placed within the woody-free zones around embankments or drainage structures.

Seed Mix Special Provisions - Provide the breakdown of seed mix by species in the Special Provision rather than shown on the plans. The plans should show only the quantity of the mix, in SY, in the plant schedule. The areas to be seeded with each mix should be graphically indicated on the plans, and calculations for either acreage or square yardage should be provided.

8.5 General Planting Guidelines

- Low Maintenance Planting – Avoid the use of mulched planting beds unless appropriate and there is a commitment for maintenance from LOD.
- Woody trees and shrubs should not be planted where a pond liner is used. Shrubs may be used if there is sufficient planting soil. Herbaceous species may be allowed depending upon the depth of cover at the liner, but installation procedures should involve hand digging rather than augers.
- Organic filters and bioretention facilities have underdrains. Plants should be selected so that their roots do not grow deep enough to clog underdrains. If the bioretention soil mix (BSM) is ≤ 4 ft. deep, the largest woody species should be understory trees. Canopy trees should not be used in bioretention facilities because there is not enough soil and the underdrains could be damaged.
- Mowability should be addressed in the planting zones so that planting does not inhibit equipment accessing critical areas to be maintained.
- The sight distance at intersections, ramps, and driveways should be checked (*AASHTO Roadside Design Guidelines, Chapter 3*).
- Use of species of the Fraxinus genus is not permitted on SHA projects.
- Temporary seeding and mulching should be provided where appropriate.
- Aquatic benches are an excellent opportunity for landscape plantings.
- Low Maintenance Planting – Avoid the use of mulched planting beds unless appropriate and there is a commitment for maintenance from LOD.
- Woody trees and shrubs should not be planted where a pond liner is used. Shrubs may be used if there is sufficient planting soil. Herbaceous species may be allowed depending upon the depth of cover at the liner, but installation procedures should involve hand digging rather than augers.

- A Visual Quality Monitor specification would be suitable for the project if there are sensitive issues related to aesthetics. Note that a task will need to be set up for the person to fill this role and this person should attend the pre-construction meeting to introduce themselves to the contractor and construction engineer. See ***Appendix H*** for an example of a Visual Quality Monitor Special Provision.

- Additional watering is incidental to plant cost per the 2008 SHA Standard Specifications for Construction and Materials.

- Seed mixes should consist of appropriate species. The pounds per acre should be sufficient to establish a good cover. Species and application rates for project-specific mixes shall be approved by the Landscape Operations Division.

- The delineation of the area of the core trench of a SWM pond shall be shown on the planting plan to ensure that no woody vegetation is planted on the pond embankment.

- Edge of liners shall be shown on the planting plan so the contractor will be cognizant and take care not to puncture it in installing plant material.

- For plantings located a significant distance from motorized equipment access, or where trees are to be installed on slopes steeper than 4:1, a reduction in the minimum size may be appropriate. Where reduction in the size of individual planting stock is necessary, SHA may require an increase in the quantity of trees to provide an equivalent total caliper measurement for the project. For example, on a 3:1 slope, four 1.5 inch caliper trees may be substituted for three 2 inch caliper trees. On slopes greater than 3:1, use of material over 1 ¾ caliper is not recommended.

- Turf grass should be established at the access road if topsoil is applied.

8.6 Vegetation Management

- If an existing facility or site is overgrown and has invasive species, appropriate vegetation management specifications should be included, subject to review and approval by SHA-Landscape Operations Division.

- Crew days or a lump sum amount to accompany vegetation management performance specifications should be included in the bid items to cover the vegetation management.

Section 9 - Soil Stabilization

9. Soil Stabilization

Soil stabilization is necessary in certain circumstances. Vegetative soil stabilization is the preferred and is suitable for most areas within a stormwater management facility. In some cases, additional measures may be necessary to ensure vegetative cover and stable soils. Soil stabilization matting should be considered first. Rip rap should only be used when vegetation and soil stabilization matting will not adequately protect soil from erosion.

9.1 Soil Stabilization Matting

Soil Stabilization Matting (SSM) is used as a mulch to enhance seed germination and establishment, to reduce soil erosion, and to reinforce the root zone of turfgrass or other groundcover vegetation after establishment. Different types of SSM are used for these purposes in level areas, on slopes, and in channels as specified in *Section 709* of the *SHA Standard Specifications for Construction Materials, July 2008*.

Approved types of SSM include the following:

- Type A: A degradable, non-permanent matting composed of excelsior (non-woven, shaved wood) that is rolled out directly over prepared and seeded soil. It has a lifespan of about 12-24 months and is best used for the following:
  - In lieu of straw mulch to avoid the mulch floating away
  - On slopes or channels where straw mulch or wood cellulose mulch binders could wash away
  - In areas where rapid establishment is desirable

Example of a facility with Type A Matting used on side slopes. Photo Credit: EPA

- Type B: A non-degradable, permanent matting composed of non-woven synthetic fibers that is rolled out directly over prepared and seeded soil. It is best used for the following:
  - In channel bottoms where established turfgrass alone will not be able to withstand erosive forces from water velocity
  - In areas with moderate risk of erosion

- Type C: A non-degradable, permanent matting composed of a synthetic fiber lattice that is rolled out directly over prepared and seeded soil or used on top of soil infill. It is best used for the following:
  - In channel bottoms where established turfgrass along with Type B matting will not be able to withstand erosive forces from stronger water velocity
  - In areas with high traffic to provide resistance to rutting

- Type D: A degradable, non permanent matting composed of woven coconut fibers that is rolled out directly over prepared soil. It has a lifespan of 24 to 36 months and is best used for the following:
    - In areas where specified vegetation is able to withstand erosive force of water velocities after the plants are established, such as along stream banks, wetlands, or along moderate to steep slopes

- Type E: A degradable, non-permanent matting composed of non-woven straw or coconut fibers that is rolled out directly over prepared soil. It has a lifespan of 6 to 12 months and is best used for the following:
    - Flat areas with low risk of erosion and where straw mulch is objectionable, such as near SWM facilities where straw mulch could wash away
    - In areas with small disturbances
    - In areas where rapid establishment is desirable

9.2 Riprap Aprons, Channel Lining, Check Dams and Outfall Stabilization

Riprap stone used at SWM facilities that are visible from the roadway and/or adjacent properties shall be dark brown or gray in color. No white or light grey riprap should be used in those instances.

Example of dark grey rip rap used for check dams in a bioswale

Section 10 - Site Development Criteria Review Process

10. Site Development Criteria Review Process

A site development review process will be conducted on all SHA projects to ensure that SWM facilities address the criteria within this document. This program is managed through the Office of Highway Development (OHD) Highway Hydraulics Division (HHD) with assistance from SDC reviewers.

HHD has a team of on-call consultant reviewers to ensure the project includes considerations for site development criteria. Reviewers serve HHD by providing comments and guidance on a variety of facility types. In particular, the SDC Reviewers role is as follows:

Assess Appropriateness of Facility Design – Ensure that the proposed design will adequately address the site's unique requirements. Refer to *Section 2, Stormwater Management Design Considerations* for a detailed description of the various mandates and considerations that may be required.

Assess Maintenance Accessibility – The facility must be designed so that it will be accessible to maintenance crews with limited specialized maintenance requirements. Refer to *Section 6, Maintenance Access* for more information.

Assess Safety Precautions – SHA will maintain ownership of these facilities, and may be liable for any negligent design features that can cause harm to maintenance workers or trespassers. Safety precautions can reduce or prevent accidents or injury potential.

Assess Landscaping – Groundcovers and landscaping is required for soil stabilization, and many facility types require additional landscaping for nutrient uptake, thermal impact mitigation, invasive species control, habitat enhancements and beautification. Refer to *Section 8, Planting* for more information.

Assess Visibility and Context – The focus does not need to include aesthetics if the facility is not visible from the road, other transportation facilities, or surrounding sensitive land uses. If the facility is visible from intensive uses such as residences, institutions, commercial areas and recreation areas or from high-use transportation facilities such as park-and-ride facilities or highway loop ramps, particular attention should be given to aesthetics.

Identify Opportunities – Identify opportunities that can offer some advantage, such as incorporating existing vegetation, framing attractive views, complementing existing landform, and increasing green infrastructure. When adjacent to forested nodes or corridors, extend forest species into the facility where possible. When adjacent to urban areas, match or enhance the existing landscape to the extent possible.

Identify Constraints – Identify potential problems or constraints associated with building a SWM facility on the site. These can include steep slopes, sink holes, adjacent residences, airport restriction zones, forest or wetlands.

Provide Comments and Guidance – The SDC Reviewer will be available to HHD and the design team to offer comments and guidance to best meet the intentions of the site development criteria.

Reviews are conducted on SHA consultant design, in-house design, Access Permits (AP), Utility Permits (UP), and SHA District special projects. For AP or UP reviews, the developer does not use SHA standard construction specifications. The necessary information and review comments are conveyed to the developer using the access permit review process. AP/UP projects require a review of the developer's plans, SWM report and specifications. These projects also need to be in compliance with the HHD *Guidelines for Development Adjacent to State Highways*. (Contact HHD for additional information.)

10.1 The SDC Review Process

SDC reviews follow the process outlined as follows:

- SHA Highway Hydraulics Stormwater Site Development Team will assign the project to a SDC reviewer. The project SDC reviewer contacts the project SWM designer and/or HHD contact to obtain project documents for review.

  Note: The SHA SWM SDC team keeps a database of all the projects assigned for SDC review on the ProjectWise site.

- The reviewer keeps the project review database current by inputting information pertaining to their project reviews. The project review database is located on the ProjectWise site.

- The HHD lead will provide the required submissions to the reviewer at each project milestone.

- The reviewer will identify projects where visibility and context creates a high priority for aesthetic sensitivity.

- The reviewer typically performs a site visit and provides photo of the site to document existing conditions and areas of concern. The site visit may be part of the Preliminary Investigation meeting scheduled at the 30% design stage.

- The reviewer will verify the existing BMP inspection results, volume considerations, soils information and presence of any environmental features.

- The reviewer will assess if the proposed design is appropriate for the setting and identify any concerns and recommendations for improvement.

- The reviewer will then produce a comment letter along with a completed checklist for each SWM facility that will be distributed to the SWM SDC team and the HHD project contact. The checklist can be viewed in ***Appendix I***. Photos, review comment letters, project information, and contact lists will be stored on ProjectWise.

- The HHD lead and the reviewer will continue to coordinate throughout the project milestones to ensure that comments are addressed and new information is received and reviewed. Reviewers will coordinate their comments through the HHD project assignee keeping the SHA SDC team copied on all correspondence and emails.

- In cases where SDC criteria conflicts with other projects goals and the reviewer and designer reach an impasse, the SDC reviewer will elevate the issue to the SHA SWM SDC Team for conflict resolution and assistance with unusual situations.

10.2 SDC Review Submission Requirements

Part of the review process includes ensuring that the submitted plans, details, and specifications provide accurate data and that facilities are appropriate for the site and desired outcome. This is important for safety and for proper function of the SWM facility. In order to accomplish this, having the right documents to review is important. *Table 10.1* shows the submissions required for each major project milestone.

Table 10-1. SDC Review Submittal Requirements

Project Milestone	**Materials Required for Review**				
	Plans	SWM Report	**Proposal Book/ Special Provisions**	**Estimate**	**Project Schedule**
PI or Before	X				X
Semi –Final	X	X	X	X	X
Final	X	X	X	X	X
Ad	X		X	X	X

PDF versions of these documents are preferred, but if only hard copies are available, the following quantities should be submitted:

- 2 copies SWM grading/layout plans, details including outfall structures, planting plans and details (half-size sets are preferred).

- 1 copy SWM report including drainage area mapping (can be returned when the review is complete).

- 1 copy IFB (Bid Book) for the project.

- A schedule including anticipated dates for Preliminary Investigation (PI), Semi-final Review (SFR), Final Review (FR), Advertisement, Bid Opening and Notice to Proceed.

10.3 SDC Reviewer Requirements

Contract Documents should be checked for accuracy and thoroughness. SDC Review comments are due within three weeks of the time that the review package was assigned, unless otherwise noted by the project manager. Comments should be provided in a letter format addressed to the HHD Division Chief, under the attention of

the HHD project assignee. An SDC checklist for each SWM facility and any other supporting data, such as sketches or photographs, should be provided as an attachment to the letter. The letter and all its attachments should also be posted on ProjectWise the same day as the submission to HHD.

The items listed below are representative of the primary items requiring review, to check for compliance with the criteria established in the previous sections of this guideline. In addition to these items, a SWM Report and milestone schedule should be reviewed.

Plans -

- Stormwater Management Plans
- Stormwater Management Details
- Grading Plans
- Landscape Plans
- Utility Plans and /or Lighting/Sign Plans
- ESC Plan (for the need to temporary fencing)

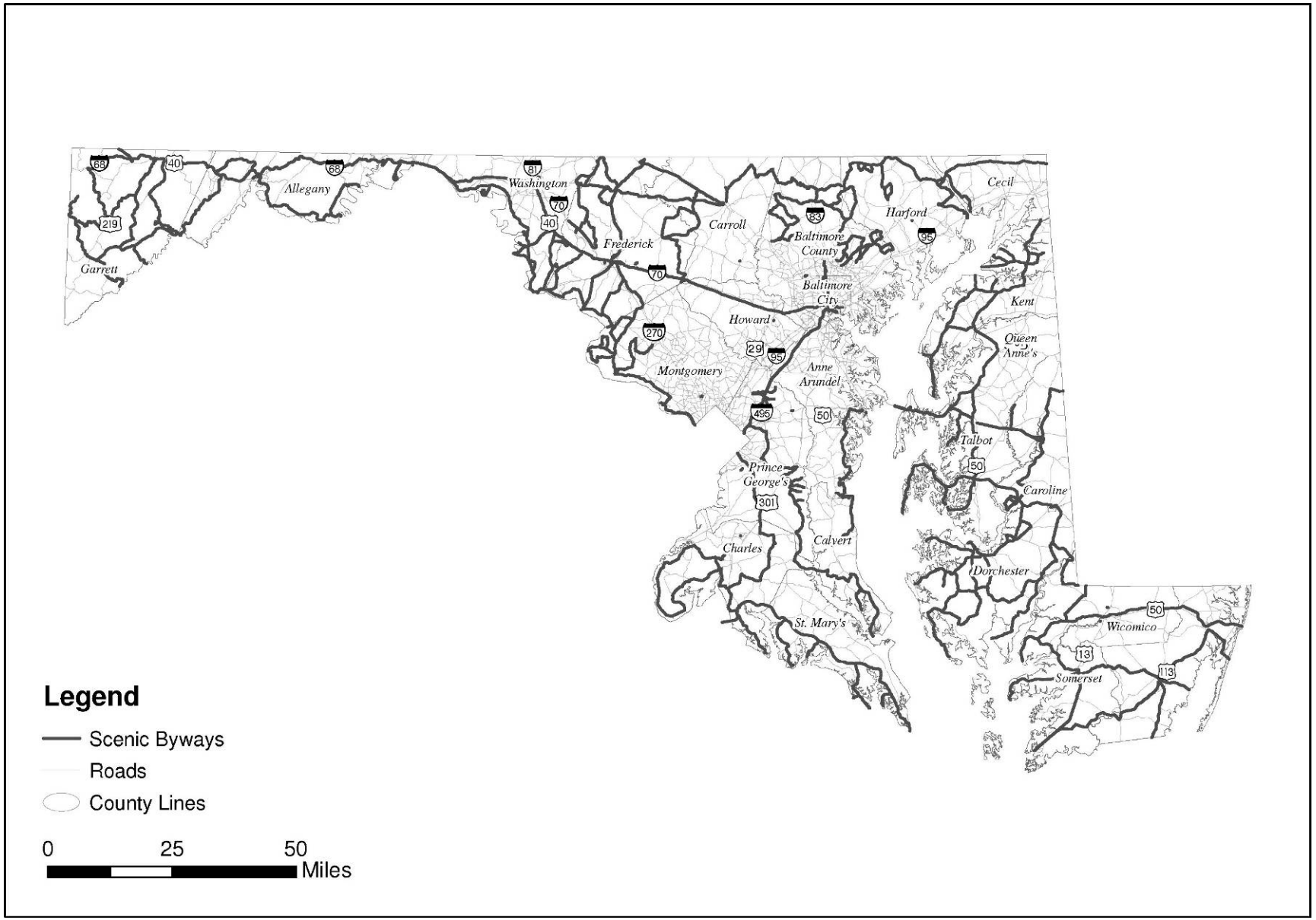
Special Provisions

- Standard special provisions (SP) are available from SHA HHD for the individual stormwater management facilities types.
- Coordinate with Maryland SHA standard details for SWM types.
- Nutrient management plan from LOD.
- SWM BMP As-Built Certification SP – ensure the latest version is included. Check the planting plans for SWM facilities requiring planting As-Built Certification (Bioretention, Stormwater Wetland) to ensure the planting As-Built checklist is used instead of the standard planting schedule.
- SP for Stabilized Maintenance Access Road.
- Wildflower seeding, coordinate with LOD. Check the special provision to ensure that the Contractor and NOT SHA is providing the seed material. SHA no longer supplies wildflower seed for construction projects.
- SP for staining or integral color into outfall structure.
- SP for top rail at chain link, if appropriate.
- Check with SHA HHD to determine if a Visual Quality Monitor is necessary. If so, ensure VQM SP is included.
- Other special provisions as needed to ensure proper installation.

Estimate

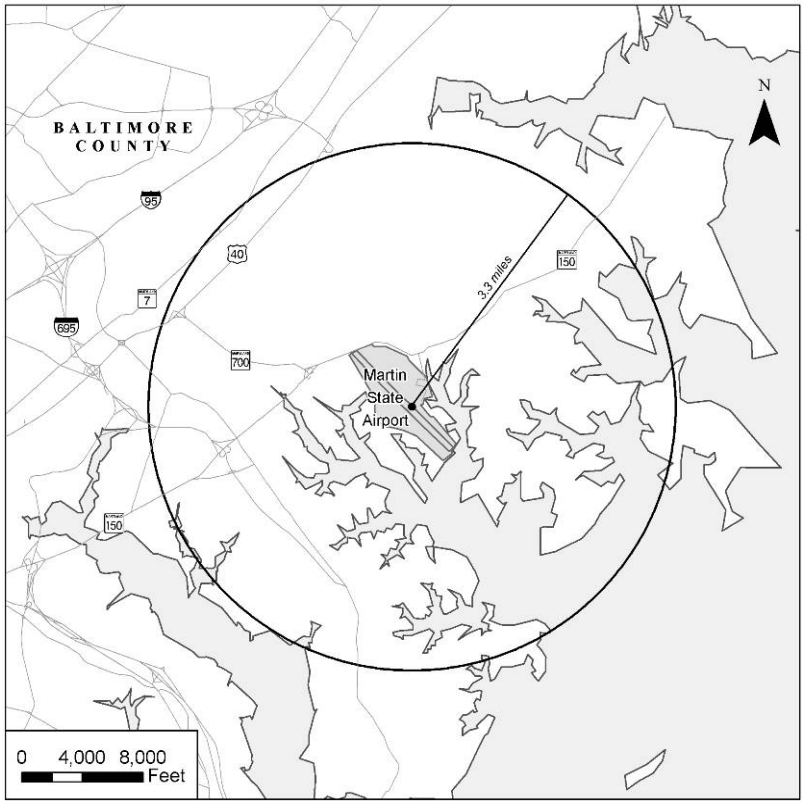
- Check quantities on plan and in planting schedules; note errors in comment letter.
- The master plant schedule quantities should be checked against individual plans.
- Bid items in Invitation for Bids book should match descriptions and quantities as represented in the plans and special provisions.

APPENDIX A



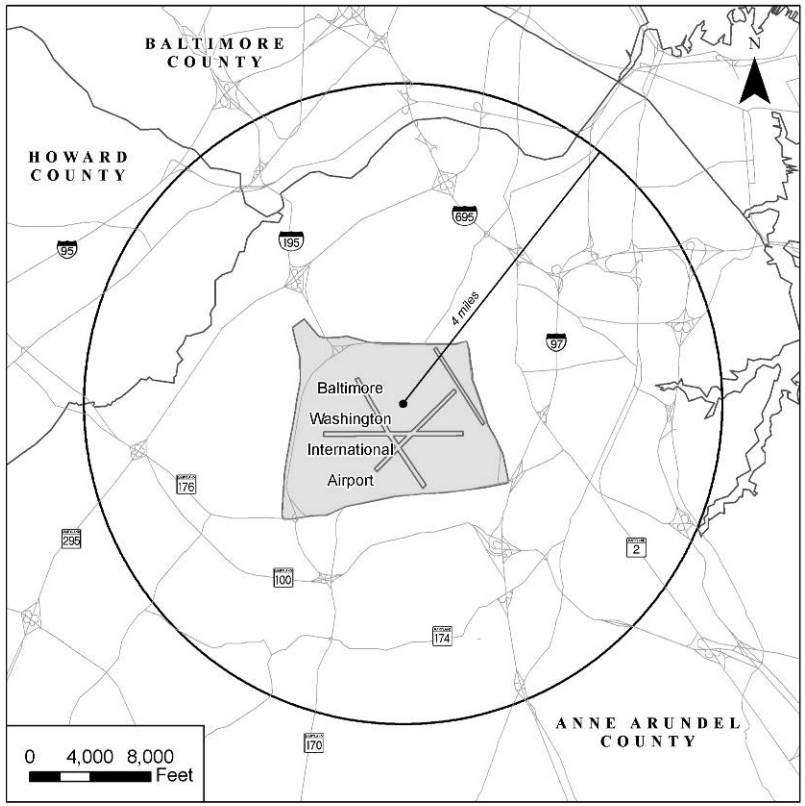
Maryland Scenic Byways

APPENDIX B



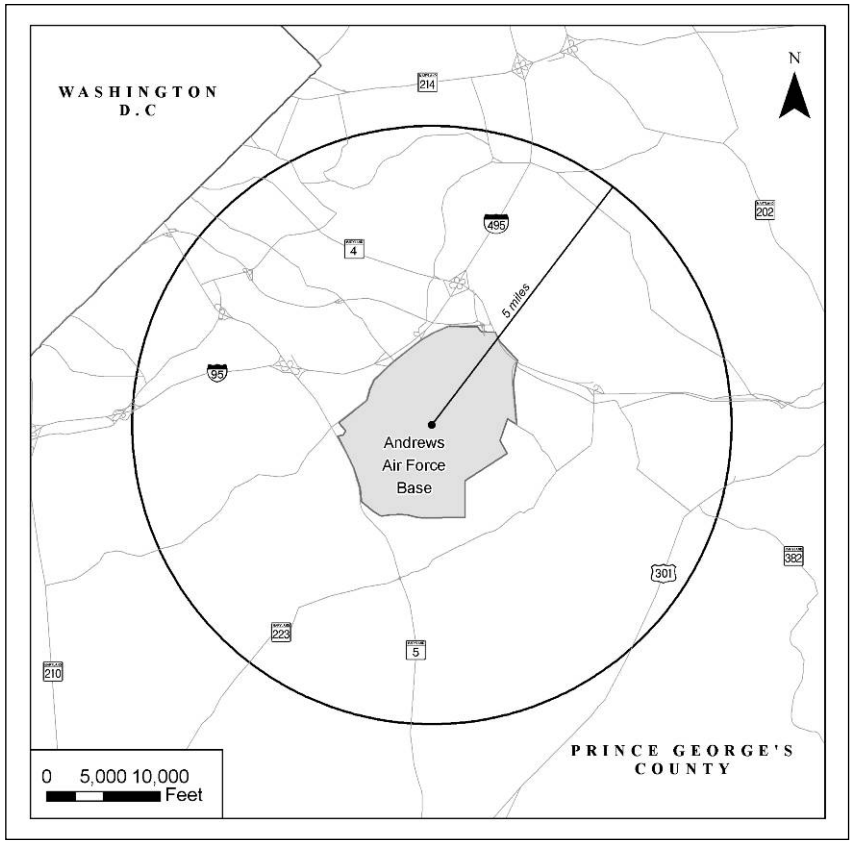
Note: The Martin State Airport Zoning District is delineated by and contained within a circle, the radius of which is 3.3 miles from a point with Maryland grid coordinates of E 1,478,185.03—N 604,718.69 (COMAR Title 11.03.06.03).

Martin State Airport Zoning District



Note: The BWI-Thurgood Marshall Airport Zoning District is the land area delineated by and contained within a circle, the radius of which is 4 miles from a point with Maryland grid coordinates of E 893,909.99—N 490.279.30 (COMAR Title 11.03.06.03).

BWI Airport Zoning District



FAA Restrictions at Andrews Air Force Base

FAA Restrictions at Patuxent Naval Station

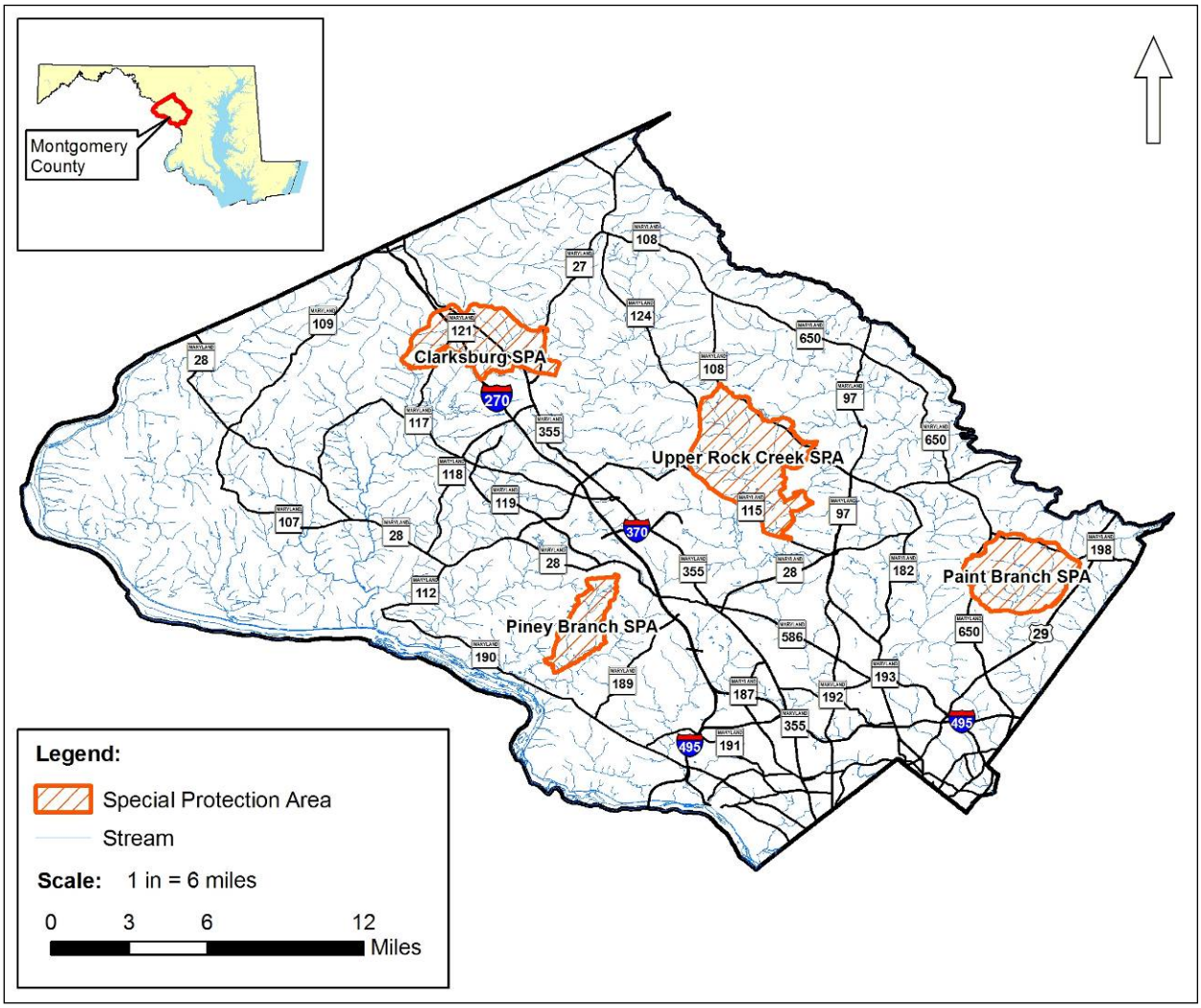
APPENDIX C

Coastal Bays Watersheds

APPENDIX D

Severn River Watershed

APPENDIX E



Montgomery County Special Protection Areas (SPAs)

APPENDIX F

APPENDIX G

MARYLAND STATE HIGHWAY ADMINISTRATION
HIGHWAY HYDRAULICS DIVISION, C-201
707 NORTH CALVERT STREET
BALTIMORE, MD 21202

STORMWATER MANAGEMENT FACILITY FENCING APPROVAL REQUEST

We hereby submit this request to fence the following proposed stormwater management facility:

Project Information:

FMIS No.: Construction No.:

Project Description:

HHD Project Contact:

Requested by:

Name: Company Name:

Phone No. Fax No.

BMP #	Facility Type	Proposed Water Depth (ft.)	Type of Fence to be provided (color, height, material)

Reason for Request:

I represent that every effort was made to design this facility with integral safety features including adjusting the size and grading of the facility and performing additional computations and analysis in order to avoid fencing.

_____ _____
Signature Date

Please submit one (1) copy of the facility grading plan, planting plan, structure details and two (2) copies of the facility fencing plan and details. A copy of the approved fencing plan will be returned to you along with this approved exemption request.

Recommended for Approval:

_____ _____
HHD SWM Safety Manager Date

Approved:

_____ _____
Chief, Highway Hydraulics Division Date

APPENDIX H

APPENDIX I

Contract No.: _____ Reviewer Initials: _____

Project Name: _____ Reviewer Consultant Firm: _____

Facility ID.: _____ Date Received: _____

Review Stage: _____ Date of Review: _____

Meeting Design Criteria?

Site Considerations

Yes	No	Deferred*	N/A	
				1. Describe surrounding context and land use: _____
				2. Is the facility along a Scenic Byway Corridor?
				3. Is the facility within a Scenic Rivers watershed?
				4. Is the area potentially a stormwater hot spot?
				5. Is the facility within 5 miles of an airport?
				6. Is the facility within a Use III or IV stream watershed?
				7. Is the facility within an impaired watershed?
				8. Is the facility within the Chesapeake Bay Critical Area?
				9. Is the facility within the Coastal Bays Watershed?
				10. Is the facility within the Severn River Watershed?
				11. Is the facility within a Montgomery County Special Protection Area?
				12. Has the site been reviewed for Hazardous Materials?
				13. Is the location known to have Karst Topography?

Soil Considerations

Yes	No	Deferred*	N/A	
				1. Do soils have high infiltration rate?
				2. Are there sufficient nutrients in the soil to sustain plantings?

Environmental Compliance

Yes	No	Deferred*	N/A	
				1. Is the Stormwater Management Limit of Disturbance included in Environemtnal planning documentation? Coordinate with EPLD
				2. Are impacts to trees inlcuded in tree removal permits? Coordinate with LOD
				3. Are impacts to wetlands or streams avoided? Coordiante with EPD

Data / Computation Check

Yes	No	Deferred*	N/A	
				1. Is facility visible from the roadway?
				2. Type of facility proposed: _____
				3. Check MD Stormwater Design Manual Ch. 2 and App. A. Is type appropriate?
				4. Does facility meet minimum volume required?
				5. Are landforms/baffles included when volume has extra capacity available?
				6. Does design take advantage of potential volume upstream for WQ?
				7. Is this an existing facility? No Yes (BMP #_____) obtain latest inspection report, incorporate recommendations into comment letter.

Form / Grading

Yes	No	Deferred*	N/A

1. Curvilinear form, or shape appropriate to context?
2. Appropriate baffles included for visual interest and to lengthen flow path?
3. Are all areas requiring routine mowing 4:1 or flatter?
4. Benches provided around permanent pools 2 feet and deeper?
5. Benches are 15' wide, with maximum slope 12:1?
6. If cut slopes are steeper than 4:1, are they forested?
7. If slopes are steeper than 4:1, is fencing proposed?

Outfall Structure

Height of structure : _____ Dimensions: _____

Yes	No	Deferred*	N/A

1. If height $\geq$ 30", is 4'-2" provided from manhole edge to riser edge on 2 sides?
2. If distance $\geq$ 48" from riser top to ground surface, is top rail/fence provided?
3. If structure is on a bench, is there 5' clear from structure to water edge?
4. Is structure context-appropriate and visually attractive?
5. Are trash racks visually attractive?
6. Is low flow device appropriate and unobtrusitve? (Submerged is preferred)

Safety / Fencing

Yes	No	Deferred*	N/A

1. If fencing is proposed, has Consultant obtained design exception from HHD?
2. Are railings provided on structures 48" high or greater (measured from ground)?
3. Does fencing/rail meet top rail requirements?
4. Does fencing/rail meet color requirements?
5. Does fencing/rail meet 42" height requirement?
6. Is placement visually unobtrusive?
7. Is there a 12' wide double gate for access? (Lockable w/2 keys provided to SHA)

Maintenance Access

Yes	No	Deferred*	N/A

1. Is access shown to bottom of facility, forebay bottoms, and all structures?
2. Is width of access 12 feet minimum?
3. Does access detail provide 4" topsoil over 6" cellular containment material?
4. Are turnarounds provided where necessary for vehicles?
5. Is longitudinal slope of access 12% or flatter?
6. Is the surface of the access road at least 1' above permanent water surface?
7. Is the entrance free from obstruction by any barriers, parking spaces, etc?

Planting

Yes	No	Deferred*	N/A	
				1. Woody material meets required Code 378 restrictions?
				2. Woody material clear of proposed pond liner?
				3. Have native species been chosen?
				4. Planting configuration in natural, colonization patterns?
				5. Proper plantings in submerged aquatic zone?
				6. Proper plantings in emergent & floating aquatic zone?
				7. Proper plantings in frequently fluctuating zone?
				8. Proper perimeter shade plantings?
				9. For filtering practices, are Sod and Seed/Mulch applications correct?
				10. For Bioretention or Sand Filter, are trees clear of underdrains?
				11. For Bioretention, are shrubs and herbaceous layer adequate?
				12. For Bioretention, is 3" deep shredded hardwood mulch provided?
				13. Site distance: Stopping (@ ramp) Turning (@ intersection) not hindered?
				14. For facilities with liners, is hand augering specified in a note?
				15. Soil Stablization Matting used where possible instead of riprap?

Specification/Bid Item Issues for Plants:

Yes	No	Deferred*	N/A	
				1. Is "additional watering" provided for upland plants?
				2. If Visual Quality Monitor seems appropriate, is it provided for?
				3. Is Seed mix the proper species?
				4. Do plant species meet LOD requirements? (Green Ash is banned)
				5. Is Vegetation Management spec appropriate?

Details

Yes	No	Deferred*	N/A	
				1. Cleanouts and Vents - aesthetically pleasant if visible?
				2. Visible riprap - is it brown or gray?
				3. Visible Concrete Structures - is pigmented concrete used where it should be?
				4. Is low-flow device either unobtrusive or submerged?

Special Provisions

Yes	No	Deferred*	N/A	
				1. Standard Special Provsions for BMP included?
				2. Nutrient Management Plan included?
				3. SWM As Built Certification included?
				4. Stabilized Maintenance Access road included?
				5. Pigmented Concrete Structures included?
				6. Top rail for chain link fence included?
				7. Compost blanket application spec included?

Yes	No	Deferred*	N/A

Estimate

1. Do plan quantities match schedules?
2. Does master plant schedule match individual plan sheets?
3. Do plan quantities match bid item quantities/descriptions?

Reviewer Documentation

1. Date of field visit _____
2. Location of Review Documents: _____

Additional Reviewer Notes:

APPENDIX J

GLOSSARY OF TERMS

Airport Zoning District: Area within which land uses, obstructions, and wildlife attractants that are incompatible with airport operations are prohibited.
Baffle: A peninsula-like land feature used to extend water flow within a pond facility
Bench: A flat area along a slope following contour lines
Bioretention Areas: Shallow depression filled with sandy soil, topped with a thick layer of mulch, and planted with dense vegetation that uses soil, plants and microbes to treat stormwater before it is infiltrated or discharged.
Best Management Practices (BMP): Control measures taken to mitigate changes to both quantity and quality of urban runoff caused through changes to land use.
Cellular Confinement System: A honeycomb-like structure that is filled with sand, soil, rock or concrete for erosion control, soil stabilization, flexible channel linings, load support and earth retention.
Channel Protection Volume (CPv): The volume used to design structural management practices to control stream channel erosion.
Coastal Bay: Assawoman, Isle of Wight, Sinepuxent, Newport, and Chincoteague bays.
Dry Swales: An open structure of moderate width and gentle side slopes that removes pollutants while also conveying stormwater.
Emergency Spillway: An open channel that is constructed beside an embankment to convey flows that are greater than the principal spillway's design discharge at a non-erosive velocity to an adequate channel.
Endwalls:
Environmental Site Design (ESD): A land planning and engineering design approach to managing stormwater runoff that emphasizes use of on-site natural features and an watershed approach to protect water quality.
Environmental Stewardship: Activities undertaken to improve the quality of the existing environment.
Evapotranspiration: A term used to describe the sum of evaporation and plant transpiration from the Earth's land surface to atmosphere.
Filter Strips: Vegetated areas situated between surface water bodies and cropland, grazing land, forestland, or disturbed land where sediment, organic material, nutrients and chemicals can be filtered from runoff.
Flow Path: The direction of water moving through a wet basin from the forebay to the outfall.
Forebays: A small pool located near the inlet of a storm basin or other stormwater management facility designed as an initial storage area to trap and settle out sediment and heavy pollutants before they reach the main basin.
Frequently Fluctuating Zone: The area between the permanent water surface and the 10-year water surface elevation.
Grass Channels: Vegetated open channels designed to filter stormwater runoff.
Green Infrastructure: Strategically planned and managed networks of natural lands, working landscapes and other open spaces that conserve ecosystem values and functions and provide associated benefits to human populations.

Headwalls: The vertical wall face of a culvert
Herbaceous Plantings: Plantings that have leaves and stems that die down at the end of the growing season to the soil level. They have no persistent woody stem above ground.
Hydrologic Soil Group (HSG): A group of soils having similar runoff potential under similar storm and cover conditions.
Hydrology: The movement, distribution, and quality of water throughout Earth.
IFB: Invitation for Bids book.
Infiltration Basin: A shallow artificial pond that is designed to infiltrate stormwater though permeable soils into the groundwater aquifer.
Infiltration Rate: A measure of the rate at which soil is able to absorb rainfall.
Infiltration Trench: an excavated trench backfilled with a stone aggregate, and lined with filter fabric used to remove suspended solids, particulate pollutants, coliform bacteria, organics, and some soluble forms of metals and nutrients from storm water runoff.
Inlet Structure: The structure that empties storm water into the stormwater management facility
Liner: An impervious layer provided in a stormwater management facility to inhibit ground water infiltration. Liners are typically used in locations with contaminated soil or karst topography.
Low-Impact Development (LID): A land planning and engineering design approach to managing stormwater runoff that emphasizes conservation and use of on-site natural features to protect water quality.
Outfall Riser: A box-like structure that controls water level and has an opening above the permanent water surface elevation to serve as an emergency overflow device during heavy storm events
Permanent Pool Elevation: The anticipated water level in a wet stormwater management pond under typical conditions.
Rain Garden: A common name for a bioretention facility, often times without an underdrain system
Riprap: Rock or other material used to armor shorelines, streambeds, bridge abutments, pilings and other shoreline structures against scour, water or ice erosion.
Scenic Byways: Roads recognized by the State of Maryland as Scenic Byways based on significant archaeological, cultural, historic, natural, recreational, and/or scenic qualities.
Sediment Basins: A temporary pond built on a construction site to capture eroded or disturbed soil that is washed off during rain storms, and protect the water quality of a nearby stream, river, lake, or bay.
Soil Stabilization Matting:
Stormwater Outfall Structures: Any structure (man-made or natural) where stormwater from highways is conveyed off of the right-of-way into .
Surface Sand Filter: A filtration system for runoff that consists of a pretreatment basin, a water storage reservoir, flow spreader, sand, and underdrain piping that is intended to address the spatial constraints that can be found in intensely developed urban areas where the drainage areas are highly impervious.
Underdrain: A drain, installed in porous fill, for drawing off surface water or water from the soil, as under the slab of a structure.
Water Quality Volume (WQv):

Watershed Approach: An approach for making sound infrastructure and growth decisions within the context of how water flows through a watershed. Water quality improvements are targeted for areas where they will provide the greatest benefit within the watershed.

Weir Structure: A small overflow-type dam commonly used to raise the level of a river or stream.

Wet Swales: A grassed open channel consisting of a broad open channel capable of temporarily storing water.