CSN TECHNICAL BULLETIN No. 6
Version 2.0

Users Guide for the ESD to the MEP Compliance Tool

Released June 15, 2010

		Hydrologic Soil Group B						
%I	RCN*	P_E = 1"	1.2"	1.4"	1.6"	1.8"	2.0"	2.2"
15%	67	**55**						
20%	68	60	**55**	**55**				
25%	70	64	61	58				
30%	72	65	62	59	**55**			
35%	74	66	63	60	56			
40%	75	66	63	60	56			
45%	78	68	66	62	58			
50%	80	70	67	64	60			
55%	81	71	68	65	61	**55**		
60%	83	73	70	67	63	58		
65%	85	75	72	69	65	60	**55**	
70%	87	77	74	71	67	62	57	

Important Note: This technical bulletin is intended to accompany Version 2.0 of the ESD to MEP spreadsheet compliance tool. The tool was developed to simplify compliance with the 2008 MDE stormwater management regulations. The spreadsheet was tested on a wide variety of sites by numerous stormwater engineers across the state of Maryland during a three-month testing phase. Special thanks are extended to them for detecting several bugs and providing active feedback throughout the testing stage. Please discard the previous test version of the spreadsheet.

This new version fixes several bugs and is ready for use in training, concept design, and final design, subject to acceptance by your local stormwater review authority. It was developed by Greg Hoffmann (Center for Watershed Protection) and Tom Schueler (Chesapeake Stormwater Network).

Background on the ESD to MEP Compliance Tool

The Maryland Legislature enacted the Stormwater Management Act of 2007 which established stringent requirements to implement Environmental Site Design (ESD) to the Maximum Extent Practicable (MEP). The Maryland Department of Environment (MDE) subsequently released regulations and design guidance that local stormwater authorities are required to implement through local ordinance by May 4, 2010.

A major implementation issue is how can designers certify and plan reviewers verify that a stormwater plan actually achieves the ESD to MEP criterion. This is an important since ESD compliance at each development or redevelopment site requires progressive and incremental accounting of the effect of better site design, alternative surfaces, disconnection credits and micro-ESD practices on post-development hydrology. This spreadsheet tool and users guide was created to fill the gap and provide a common and unified basis for effective local ESD design and plan review.

Experience in Virginia has shown that spreadsheets can be a versatile design tool to quickly test the best combination of ESD practices to apply to each unique site (VA DCR, 2009). The spreadsheet approach used in Virginia, however, required several major adaptations to conform to the specific ESD methods and requirements outlined in MDE (2008). For example, with the exception of the Critical Area, Maryland does not explicitly require numeric nutrient reductions from individual development or redevelopment sites.

The ESD to MEP spreadsheet can be used in two stages of the local stormwater plan review process. The first stage is during early stormwater concept design, where it is used to optimize the combination of ESD practices used at a site to determine whether it can meet the ESD to MEP criterion. The second stage is to confirm the adequacy of the ESD system as part of the final stormwater design submittal (i.e., after each individual ESD practice has been designed).

2.0 Features of the ESD to MEP Compliance Tool

The spreadsheet has several features that automate and simplify the local plan review process. For example, the spreadsheet:

- Serves as an excellent training tool for design engineers to familiarize themselves with the sequence of ESD practices, and test which combinations of practices work best on real-world development sites.

- Quickly calculates ESD treatment volume for new development projects using the MDE “woods in good conditions” method, based on simple data inputs.

- Also calculates the water quality volume that must be treated at redevelopment sites, based on the net change in existing impervious cover created by the project. If the redevelopment project increase site impervious cover, it also calculates the additional increment of recharge, water quality and channel protection that must be provided as a result of the extra impervious cover.

- Progressively accounts for runoff reduction by a series of different ESD credits and practices across the site.

- Allows designers to analyze complex sites, by running the calculations for the site as a whole to determine ESD requirements as whole, and then analyzing a series of small (3 to 5 acre) sub-drainage areas to provide more detail, Due to the structure of the spreadsheet, it was not possible to include multiple drainage areas within the same spreadsheet. This means that that designers must prepare a simple table or master spreadsheet that documents how ESD over or under control within individual sub-drainage areas meets the total ESD volume for the site as a whole.

- Clearly shows plan reviewers whether ESD to the MEP criterion has been achieved or not, and enables designers to quickly test alternative combinations of practices to achieve compliance.

- Computes reductions in curve number due to the implementation of ESD practices to help determine the runoff storage needed for channel protection (Cpv) and peak discharge events (Qp) up to the 2 year design event.

- Includes the ability to track phosphorus reductions, as required for development projects located in the Intensely Developed Areas of the Maryland Critical Area. These phosphorus calculations have been integrated within the new ESD to MEP framework, which provides, for the first time, a unified basis for addressing both the MDE and Critical Area stormwater regulations in a single tool. This feature should help streamline review of these projects and reduce the need for duplicate submittals. Designers should note that Critical Area IDA projects currently have a lower minimum area threshold (500 square feet-sf) that triggers stormwater requirements than the statewide threshold of 5000 sf.

3.0 Caveats and Limitations of the Spreadsheet

The ESD to MEP compliance tool was jointly developed and tested by CSN and CWP and generally conforms to the MDE stormwater regulations and technical guidance contained in Chapter 5 of the revised Stormwater Manual (MDE, 2008). In some cases, minor simplifications were made to facilitate easier site analysis. Local stormwater review agencies are encouraged to adapt and modify the spreadsheet to reflect their unique policies, technical criteria and plan review requirements. The Critical Area component of the spreadsheet should still be considered draft until it is finalized by DNR in early fall of 2010. The spreadsheet is expected to evolve over time to incorporate new stormwater technology and performance research, and local experience with the design and maintenance of ESD practices.

CSN offers it as a free, open source Excel spreadsheet to compute ESD requirements and assists in the sizing of many ESD practices. Neither the CSN nor CWP assume any liability for the use (or abuse) of this open-source product. Although the spreadsheet does follow the general design methods presented in MDE (2008), no official state endorsement should be inferred or construed. Designers should also consult with their local stormwater review authority about what spreadsheet outputs are needed for project submittals.

4.0 Getting Started

A number of tasks need to be performed before you use the spreadsheet. Perhaps the two most important tasks are a site recon visit and an analysis of site maps and environmental features. The minimum environmental and site mapping data needed are outlined on page 5.7 of MDE (2008), and localities often have additional mapping requirements.

The importance of early stormwater planning and analysis cannot be over-emphasized, as early decisions about site layout and the development footprint have significant consequences for ESD compliance.

These decisions are greatly improved when designers thoroughly understand the pre-development flow paths, hydrology, soils and environmental features present at the site and work with them to locate the ideal development footprint and sequence of ESD practices.

As a general rule, designers should split the site up into logical drainage areas of 3 to 5 acres or less, and try to maintain natural flow paths. Soils analysis is also important so that the most permeable soils at the site can be exploited for ESD practices as much as possible.

It is recommended that a designer create a draft site plan that shows the proposed development foot print, impervious cover areas, protected natural areas, pervious areas and basic soils information before using the spreadsheet.

5.0. Users Guide for the ESD to MEP Spreadsheet

This section provides a step by step user's guide on analyzing ESD practices using the spreadsheet, and provides general advice for designers and plan reviewers on how to most efficiently comply with the ESD and MEP criterion.

A few general notes about the spreadsheet. Blue cells require input data by designers, whereas gray cells show various ESD outputs. The equations in the spreadsheet are locked so they cannot be changed by the user. The spreadsheet calculates ESD outputs for three site conditions: new development, redevelopment and both kinds of projects within the Maryland Critical Area.

Step 1: Complete ESD Implementation Checklist

In the first step, designers analyze environmental and soil mapping to layout the site to maximize utilization of ESD practices. Designers are asked to answer 12 questions in Table 1 to determine whether they have maximized these early stormwater opportunities. The basic idea is that a compliant concept plan has a "Yes," or "N/A" selected for each question. It is recommended that designers clearly show these practices on their stormwater concept plan. In the case that a question is answered "No", the designers must provide a narrative justification as to why the practice could not be used on the project.

Table 1. ESD Implementation Checklist

Check all of the Following ESD Practice That Were Implemented at Site	Yes	No	N/A
1. Environmental site mapping was conducted prior to site layout			
2. Natural areas were conserved (e.g., forests, wetlands, steep slopes)			
3. Stream, wetland and shoreline buffers were reserved			
4. Disturbance of permeable soils were minimized			
5. Natural flow paths were maintained across the site			
6. Building layout was fingerprinted to reduce site clearing/grading			
7. Site grading promoted sheet flow from impervious areas to pervious ones			
8. Better site design was used to reduce needless impervious cover			
9. Site Design maximized disconnection of impervious cover			
10. Future site operations evaluated to identify potential stormwater hotspot			
11. Installation of ESC and ESD Practices are integrated together			
12. Tree planting was used at the site to convert turf areas into forest			

Step 2: Calculate Site Impervious and Water Quality Volume

The basic inputs for this step are simple: Site Area **(B29)**, Existing Site Impervious Cover Area **(B30)**, and Proposed Site Impervious Cover Area **(B31)**. Designers should directly measure impervious cover from the site plan. Operationally, MDE defines impervious cover as all site area that does not have vegetative or pervious cover.

The spreadsheet calculates the percentage of impervious cover for both existing and proposed conditions. If the existing site is greater than 40% impervious, redevelopment rules will apply.

The designer also needs to indicate the rainfall depth **(B32)** in order to calculate the required water quality volume. The two choices are 1.0 for the Eastern Shore, and 0.9 for the rest of the State

Step 3: Calculate Phosphorous Removal Requirement for Critical Area Sites

In this step, the spreadsheet calculates the average annual predevelopment load based upon either new development or redevelopment rules. For new development, the predevelopment load is calculated based upon a loading of 0.5 pounds P per acre per year. Redevelopment rules apply if the site is greater than 15% impervious. For redevelopment, the predevelopment load is calculated based upon the runoff coefficient and an average runoff concentration of 0.3 mg/L for total phosphorus.

The resulting phosphorus removal requirement is computed using the 10% Rule (DNR, 2003), such that that the post-development phosphorous load will be at least 10% less than the existing phosphorous load.

The phosphorus requirement **only** applies to projects located in the Intensely Developed Area (IDA) of the Maryland Critical Area. Projects designed in all other areas of Maryland **are not** required to design for phosphorus removal, but it is good practice to maximize phosphorus reduction to prevent nutrient loads to the Chesapeake Bay.

Step 4: Calculate the Environmental Site Design Rainfall Target

Designers then need to enter the percentage of the site in each of the four Hydrologic Soil Groups (HSGs) on **rows B48-51**. The soil data is used to calculate a pre-development runoff curve number (RCN), which in turn, is used to compute the ESD Rainfall Target.

For new development, the ESD rainfall target is defined as the depth of rainfall that must be treated to reduce the site's post-development RCN to the pre-development RCN.

Required recharge volume is also calculated based upon specific recharge rates for each soil type.

For redevelopment sites, the spreadsheet calculates the required water quality treatment volume for redevelopment sites, based on the net change in proposed impervious cover relative to existing impervious cover.

If the proposed impervious cover at a redevelopment site exceeds existing impervious cover, the spreadsheet also computes the incremental recharge and channel protection volume for the site. Since most redevelopment sites will be on urban fill soils (CSN, 2010), designers should generally assume that 100% of site area will behave as HSG "D" unless they have an on-site soil test to the contrary.

Designers should use this step to identify the locations of the most permeable soils present at the site in order to find the best opportunities to apply the right ESD practices.

Step 5: Select Alternative Surfaces to Reduce Target Rainfall and Phosphorous Removal Requirements

In this step, designers investigate whether green roofs or permeable pavers are an effective strategy to reduce the ESD rainfall target at the site. Designers can "deconstruct" the site to find portions of rooftops, sidewalks, driveways, plazas and other areas of the site where these alternative surfaces can be effectively employed. Designers then enter the total drainage area **(B73-79)** and thickness **(C71-79)** of each practice, for the predevelopment soil type.

The spreadsheet then computes a reduced ESD Rainfall Target based on the following RCNs for the site areas that utilize these alternative surfaces:

Green Roof						
Roof Thickness (in)	0	2	3	4	6	8
Effective RCN	0	94	92	88	85	77

Permeable Pavement			
Thickness (in)	Effective Curve Number based on soil type		
	A	B	C
0	0	0	0
6	76	84	93
9	62	65	77
12	40	55	70

In the Critical Area, the spreadsheet computes a revised phosphorous removal requirement for the site by reducing the proposed acreage of impervious cover by 50% for the surface area where alternative surfaces are used at the site.

Note: the current version of the spreadsheet does not account for any additional stormwater storage under the pavement that is intended for additional channel protection or flood control.

Step 6: Select Nonstructural Practices to Treat the ESD Rainfall Target

In this step, designers can apply up to three credits for various kinds of filter strips or corridors used to effectively disconnect impervious cover. They include:

1. Rooftop Disconnection
2. Non-Rooftop Disconnection
3. Sheet flow to Conservation Area

The designer enters the contributing impervious drainage area **(Column D)**, as well as specific design parameters that are needed to receive each credit at the site **(Column G & H).** Based on this information, the spreadsheet automatically computes an ESD rainfall target credit and an associated runoff volume credit. Credits are calculated based upon the following:

Disconnection of Rooftop Runoff						
	Disconnection Flow Path Length (ft)					
Western Shore	0	15	30	45	60	75
Eastern Shore	0	12	24	36	48	60
P_E Credit	0	0.2	0.4	0.6	0.8	1

Disconnection of Non-Rooftop Runoff						
Ratio of Disconnection Length to Contributing Length	0	0.2	0.4	0.6	0.8	1
P_E Credit	0	0.2	0.4	0.6	0.8	1

Sheet Flow to Conservation Areas				
Minimum Conservation Area Width	0	50	75	100
P_E Credit	0	0.6	0.8	1

For the Critical Area, designers must determine the predominant predevelopment HSG over the filter path to obtain the credit (i.e., A/B or C/D). This data is needed to compute differential phosphorus removal rates for these hydrological soil groups. At the current time, this more refined soil information is not used in the ESD volume reduction calculation, but this would certainly be a useful future upgrade.

Designers should always double check the actual distances and slopes of the contributing impervious areas and filter path on the site plan to ensure they conform to the minimum qualifying criteria for the credit (as outlined in Chapter 5 of MDE, 2008),

<u>Step 7: Select ESD Micro-Practices to Treat the ESD Rainfall Target</u>

The spreadsheet presents a somewhat simplified approach to handling ESD micro-practices, which include:

- Rainwater harvesting
- Submerged gravel wetlands
- Micro-infiltration (or dry wells)
- Rain Garden

- Micro-Bioretention
- Landscape Infiltration
- Grass Swales
- Bioswales
- Wet Swales

Designers can optimize which types of ESD micro-practices are most suitable for their site by analyzing the predevelopment HSG as shown in Table 2. In addition, they may want to consult Table 3 to identify which micro-ESD practices are most efficient per square foot of surface area in meeting ESD requirements, or have the capacity to be "upgraded" in size.

Table 2 Acceptable Soils for ESD Micro-Practices				
ESD PRACTICE	HSG A	HSG B	HSG C	HSG D
Permeable Paver	**X**	**X**	**X**	
Rainwater Harvesting	**X**	**X**	**X**	**X**
Submerged Gravel Wetlands			**X**	**X**
Micro-infiltration	**X**	**X**		
Rain Garden		**X**	**X**	**X**
Bioretention		**X**	**X**	**X**
Landscape Infiltration	**X**	**X**		
Grass Swales	**X**	**X**	**X**	
Bioswales	**X**	**X**	**X**	**X**
Wet Swales			**X**	**X**
Enhanced Filters			**X**	**X**
X= may be suitable depending on depth to water table, bedrock and slope				

Table 3 Comparing the ESD Micro-Practices			
ESD PRACTICE	ESD Efficiency[1]	Max CIDA [2] (sf)	Upgrade? [3]
Rainwater Harvesting	**20+**	**~20,000**	**Yes**
Gravel Wetlands	**~10**	**< 1 acre**	**No**
Micro-infiltration	**15**	**500**	**Yes**
Rain Garden	**10**	**2,000**	**No**
Micro-Bioretention	**15**	**20,000**	**Yes**
Landscape Infiltration	**20**	**20,000**	**No**
Grass Swales	**10**	**> 1 acre**	**No**
Bioswales	**10**	**> 1 acre**	**Yes**
Wet Swales	**15**	**> 1 acre**	**?**
Enhanced Filters	**~6**	**n/a**	**No**
[1] efficiency in terms of inches of ESD treatment per square foot of practice surface area (the higher the number, the more efficient the practice) [2] the contributing drainage area limits, as prescribed in MDE, Chapter 5 [3] Can the practice be "upgraded" to a Chapter 3 practice that also meets the ESD criterion (e.g., micro-bioretention upgraded to a regular bioretention area)			

Enhanced Filters can be added as a supplemental design option to the appropriate ESD practices in **Column L.** Infiltration berms are only considered a design element to improve the effectiveness of various disconnection credits in Step 5.

The appropriate hydrologic soil group associated with several ESD micro-practices must be entered into the spreadsheet; this is done to compute differential phosphorus removal rates for the Critical Area computation, as well as to clearly show the most appropriate soil conditions where they can be effectively used

In practice, this step begins with an overlay of the site layout, pervious areas and soil conditions. Designers should work to direct contiguous impervious areas to pervious areas, and draw the approximate drainage areas to each micro-practice. The spreadsheet assumes that 100% of the impervious area is treated by the individual micro-practice. The designer then estimates the surface area of the micro-practice.

The designer can then aggregate the total contributing impervious drainage area (CIDA) and surface area for each category of micro-practice for the drainage area as a whole.

The designer enters the CIDA into **Column D**, as well as any practice-specific design parameters in **Column G & H** for each set of ESD micro-practices planned for the site. One of the new features in this version of the spreadsheet constrains the practice design parameters so they do not exceed reasonable combinations of surface area to CIDA.

Where applicable, designers can select a downstream practice to which runoff from the primary ESD practice will be directed in **Column N** (e.g., bioretention to a bioswale). The spreadsheet allows for proper accounting of ESD practices in series, and produces the aggregate ESD rainfall target credit and the associated runoff volume credit for the entire system of ESD micro-practices at the site (as well as the increment of phosphorus load reduction).

Several useful ESD practices for highly urban redevelopment sites were not included in Chapter 5, but can be incorporated into the spreadsheet by selecting an existing ESD micro-practice that treats an equivalent ESD volume, For example, foundation planters should be expected to function in a comparable manner to micro-bioretention, and expanded tree pits should function like a rain-garden, in terms of the ESD volume that they handle (see CSN, 2010).

Step 8: Check Site Compliance for Water Quality Volume, ESD Rainfall Target, Recharge Volume, and Phosphorous Load Reduction, and Revise Site If Necessary

The spreadsheet summarizes the total runoff volume treated, ESD rainfall depth treated, recharge volume, and total phosphorous load reduced by the ESD practices on **lines 145 to 155.** These site values are then compared to the required reduction/treatment values in order to determine whether the site has complied with ESD to the MEP.

Operationally, this requirement is satisfied when sufficient ESD practices are used to meet:

1. The entire WQv for the site, and depending on development intensity and local plan review requirements, the entire ESD rainfall target volume.
2. The full recharge volume requirement (Rev), given the predevelopment soils present at the site,
3. The full phosphorus load reduction requirement (for projects in the IDA of the Critical Area only). It should be noted that most projects will generally satisfy this requirement if they comply with the ESD to MEP criteria.

If full compliance cannot be demonstrated for these ESD requirements, designers must re-evaluate the site to achieve greater ESD treatment. This involves an iterative process to investigate more ESD options, using the spreadsheet. Some useful strategies include:

Go Back to Step 1 and Adjust Site Layout to Reduce Impervious Cover or Increase Forest Cover. Designers should particularly focus on any of the ESD planning practices that were not used in the ESD implementation checklist

Go Back to Step 5 and Consider More Alternative Surfaces. Many designers may have skipped this step due to cost perceptions or lack of prior design experience with alternative surfaces. In these cases, designers should look at portions of the built footprint where alternative surfaces, especially permeable pavers could be most profitably used.

Go Back to Step 6 and Expand Site Area Subject to Credits. The site plan should be reexamined to determine if more impervious cover could be treated through disconnection and filter strips, either by additional disconnection, or improving the soil and slope conditions within the filter strip, using infiltration berms, compost amendments, grading, or engineered level spreaders or other measures so that a greater CIDA can be treated

Go Back to Step 7 and Apply More or Larger ESD Practices. Designers have a number of options to improve the aggregate ESD performance for the site in this step.

1. Add more micro-ESD practices to pick-up additional untreated CIDA
2. Change the mix of micro-ESD practices to increase runoff reduction (shift from grass swale to bio-swale, or from rain garden to micro-bioretention, etc.)
3. Add Enhanced Filters to select ESD micro-practices
4. Use ESD practices such as infiltration trenches, bioretention and dry swales that serve a larger CIDA (these can be entered directly into the micro-ESD spreadsheet)

It may take several spreadsheet iterations to test which combination of practices can best meet ESD to the MEP at the site.

Step 9: Determine Reduced RCN and Required Channel Protection Volume Based Upon ESD Rainfall Depth Treated

In this step, the spreadsheet automatically calculates a reduced RCN based upon the ESD rainfall depth treated in prior steps. If the required ESD rainfall depth has not been completely treated through acceptable ESD practices, this revised and reduced RCN is used to calculate the Channel Protection Volume that must be treated through structural practices, such as ponds or wetlands.

The reduced RCN values **should not be used** for the larger design storms used for flood control analysis (e.g., the 10 or 100 year design event). Instead, designers should re-compute the RCN manually by adding the depth of ESD volume achieved at the site to the initial abstraction. These updated curve numbers can then be directly incorporated into the appropriate hydrologic models, such as TR-55 and TR-20.

Step 10: Select Structural Practices to Treat the Channel Protection Volume

This step is only performed when ESD practices cannot meet either the:

- ESD rainfall target (Pe)
- Recharge volume and/or
- Critical Area phosphorus removal requirement.

Designers can then consider traditional structural stormwater practices such as ponds, wetlands, and filtering systems to obtain the remaining recharge volume, channel protection volume or phosphorus reduction, depending on their need.

In most cases, the designer will develop a structural design for the practice (or practices) at the most downstream point in the project drainage area, and then independently calculate the treatment volume, based on typical assumptions for storage and treatment for structural practices. These values should then be imported into the respective entry fields for contributing impervious drainage area (**column B**) and the design treatment volume (**column E**).

The channel protection volume achieved is then calculated based upon the sum of the treatment volumes provided for each practice. The Recharge Volume and Phosphorous Load Reduction achieved are also recalculated based on the additional structural practices utilized.

The spreadsheet shows two levels of design for structural stormwater practices, which are used to estimate their phosphorus removal capability for the Critical Area requirement. Level 1 is a baseline design using the minimum criteria for the practice as outlined in MDE (2000), whereas Level 2 is an enhanced design that maximizes phosphorus removal. The technical basis for the two design levels are outlined in CWP and CSN (2008). More detailed Level 1 and 2 design criteria will be released in the Fall of 2010 after DNR review.

<u>Step 11: Evaluate Feasibility of the Concept Plan</u>

Simply showing compliance with the spreadsheet is not sufficient to proceed to final stormwater design. Several important elements are needed to finalize the concept plan, as follows:

- A stormwater site plan should be drafted to show the spatial distribution of ESD practices in a detailed manner that plan reviewers can verify spreadsheet areas related to CIDA and ESD practice surface area.

- The designer should also analyze the site to confirm feasibility of individual ESD practices (e.g., depth to water table, depth to bedrock, contributing slopes, sheet flow distances, minimum practice surface area) using the practice limitations as outlined in MDE(2008) and/or local stormwater design supplements.

- Soil borings and infiltration testing may also be needed to confirm infiltration rates and underlying soil conditions at the site.

- Designers should also carefully review the plan to ensure safe and non-erosive conveyance of large storms through the sequence of ESD practices across the site. This analysis dictates the consequent need for overflows, flow splitters, channel stability and other measures to protect ESD practices from larger storms events, such as peak discharge of the 2 or 10 year storm design event.

- Designers must also solve the tricky problem of how to sequence installation of ESD practices in the context of plans for grading and erosion and sediment control (ESC). Many ESD practices must be protected from disturbance during construction and/or installed after the site has been permanently stabilized. At the same time, the ESC plan must provide effective controls during construction to prevent the discharge of sediments. While a few ESD practices can be used as temporary erosion and sediment controls, most cannot.

- Therefore, the designer will need to carefully think through how to properly integrate both ESC and ESD practices in a coordinated design. Table 4 summarizes the ESC restrictions for the range of ESD micro-practices. All of the practices must be installed after the site is permanently stabilized and most require that the surface area of the practice be protected by a perimeter control practices or construction fencing during construction. In addition, only a few can be used as the site for an ESC practice during construction, and nearly all of them require some sort soil of restoration if they become compacted or have sediment accumulation during construction (e.g., deep tilling, disking or compost amendments).

- Lastly, the concept plan must meet the minimum submittal requirements established by the State (i.e., pages 5.15-16 of MDE, 2008), in addition to any requirements established by the local stormwater review authority.

Table 4. ESD Practice Restrictions for Erosion and Sediment Control (ESC Plans)				
ESD PRACTICE	Install After Construct [1]	Avoid or Protect [2]	Do not use for ESC [3]	Restore Soil? [4]
Disconnect/Filter credits	**X**	**X**	**X**	**X**
Permeable Paver	**X**	**X**	**X**	**X**
Rainwater Harvesting	**X**	na	na	na
Gravel Wetlands	**X**	**X**	**X**	**X**
Micro-infiltration	**X**	**X**	**X**	**X**
Rain Garden	**X**	**X**	**X**	**X**
Micro-Bioretention	**X**			**X**
Landscape Infiltration	**X**	**X**	**X**	**X**
Grass Swales	**X**			**X**
Bioswales	**X**			**X**
Wet Swales	**X**			**X**
Enhanced Filters	**X**	**X**	**X**	**X**

Na: not applicable
[1] ESD practice cannot be installed until contributing drainage area has been permanently stabilized
[2] The surface area of the ESD practice must be protected by a perimeter control device or be located outside the limits of disturbance during construction
[3] The ESD practice cannot be used as a temporary ESC practice during construction (e.g., a sediment trap)
[4] If inspection indicate that the surface area of the ESD practice has been compacted by construction traffic, or has accumulations of eroded sediments, the soils must be restored using an appropriate method of tilling, sediment removal, and/or soil compost amendments

Step 12: Final ESD Design and Verification After Installation

The compliance spreadsheet should be run again to verify that the final ESD plan meets the ESD to MEP criterion. At this point, the CIDA, surface areas, design parameters and treatment volume for individual ESD practices can be more accurately measured and defined. The revised values should be entered into the spreadsheet to ensure that the results from the concept plan can be verified or exceeded.

The spreadsheet can be submitted as part of larger, final ESD design package. The package must meet the minimum submittal requirements established by the State (i.e., Page 5.11 of MDE, 2008), in addition to any requirements established by the local stormwater review authority.

Several steps are crucial after the final plan is approved to ensure ESD practices are properly installed. Construction inspections should be conducted to ensure ESD practice areas are protected from disturbance during the construction stage, and to determine when the site has been properly stabilized so that ESD practices can be installed. In addition, post construction inspections are needed to verify that ESD practices have been properly installed, are functioning as intended, and meet any vegetative cover requirements.

References Cited

Chesapeake Stormwater Network (CSN). 2008. Technical Bulletin No. 3: Technical Support for the Bay-wide Runoff Reduction Method. Chesapeake Stormwater Network. Baltimore, MD www.chesapeakestormwater.net

Chesapeake Stormwater Network (CSN). 2010. Technical Bulletin No. 5: Stormwater Design for Redevelopment Projects in Highly Urban Areas of the Chesapeake Bay Watershed. Version 1.0. Baltimore, MD www.chesapeakestormwater.net

Maryland Department of Environment (MDE). 2000. *Maryland Stormwater Design Manual*. Baltimore, MD. Available online at: http://www.mde.state.md.us/Programs/WaterPrograms/SedimentandStormwater/stormwater_design/index.asp

MDE, 2008. Maryland Stormwater Design Manual. Revised Chapter 5. Environmental Site Design. Baltimore, MD. Available online at: http://www.mde.state.md.us/Programs/WaterPrograms/SedimentandStormwater/stormwater_design/index.asp

Maryland Department of Natural Resources. (MD DNR). 2003. Critical Area 10% Rule Guidance Manual, Third Edition, Prepared by Center for Watershed Protection. Available at: http://www.dnr.state.md.us/criticalarea/guidancepubs/10percent_rule.html

Virginia Department of Conservation and Resources (VA DCR). 2009. Compliance Spreadsheet for the Virginia Runoff Reduction Method. Developed by the Center for Watershed Protection. Charlottesville, VA.

Appendix A
Standardized TP Removal Rates for the Critical Area

Table A-1 provides updated total phosphorus removal rates for new ESD practices and traditional stormwater practices in order to integrate the MDE ESD approach with the 10% rule.

These values are used in the ESD to the MEP compliance spreadsheet in order to track the progressive phosphorus reduction by ESD practices at a development site.

The values reflect the mass removal rate for each practice, using the VA DCR technical memo. The mass removal rate reflects the relative contribution from runoff reduction and the change in phosphorus concentration as it flows through the practice.

In most cases, the mass removal rate differs based on the hydrologic soils group of the underlying soils. In some cases, an enhanced level of design is possible to increase the P mass removal rate. The design criteria for these enhanced practices are currently being developed, and will be released later this fall.

Table 1 Adjusted Removal Rates for Critical Area Stormwater Practices					
ESD Practices	**Old CA P Rate/ Credit**	**New Data Source**	**Recommended New Rates**		**Rationale and Documentation**
			A & B Soils	**C & D Soils**	
Green Roof	Credit[1]	VA DCR	Less than 6: 45 More Than 6 : 60		Depth of vegetated roof. High runoff reduction but no change in TP EMC
Permeable Paver	Credit[2]	VADCR	80	60	Research has shown high rates of both runoff reduction and TP removal, depending on degree of soil infiltration.
Reinforced Turf	Credit [3]	Not Much	15	0	The MDE design has minimal underground storage to provide infiltration or reduction
Rooftop Disconnect	Credit[4]	VADCR	50	25	The 25% removal rate for C/D soils can be increased to 50% if it conforms to more stringent design criteria
NRD Filter Strip	None [5]	VADCR	50(75)	25 (50)	NRD = Non-rooftop Disconnection to a filter strip. Removal rates in parentheses are for enhanced filter strip design criteria by CSN
Sheet flow to Cons Area	None[6]	VADCR	50(75)	25(50)	Subject to critical area buffer restriction. Removal rates in parentheses are for enhanced filter strip design criteria by CSN
Rainwater Harvesting	None[7]	VA DCR	45%	45%	TP rates are based on the volume of runoff reused or he values a
Landscape Infiltration	None [7]	VADCR	75%	Not Allowed	This a hybrid of both infiltration and bioretention
Sub Gravel Wetlands	None [7]	UNH	Not Allowed	60%	Based on recent research from New Hampshire
Infiltration Berm	None [7]	None	0%	0%	This is not a stand-alone practice, but can help enhance NRD filter strip and grass channel performance
Dry Well	65% [8]	63% NPRD	65%	Not Allowed	Retain same rate as for infiltration practices
Rain Gardens	None [7]	VADCR	50%	25%	Several key design elements that contribute to P removal of this form of bioretention are absent
Micro-bioretention	50% [9]	VADCR	75%	50%	Performance related to degree of soil infiltration achieved
Grass Channels	Credit [10]	VADCR	40%	20 (40)	Removal rates in parentheses are for enhanced grass channel design criteria proposed by CSN
Wet Swales	40%	VADCR	Not Allowed	40 (50)	Removal rates in parentheses are for enhanced wet swale design criteria proposed by CSN

Table 1

Adjusted Removal Rates for Critical Area Stormwater Practices

Bio swales [11]	65	VADCR	75%	50%	Performance related to degree of soil infiltration achieved
Enhanced Filters	None [7]	MDE	Not Used	0%	This is only used to increase recharge volume not water quality volume
Infiltration Systems [12]	65%	VADCR	Level 1: 60% Level 2: 90%		Level 1 is the base removal rates for the practice using standard design criteria in MDE (2000). Level 2 are include additional design elements that enhance TP removal rate, following the VADCR approach
Filtering Systems [12]	50%	VADCR	Level 1: 60% Level 2: 65%		
Ponds [12]	50-65	VADCR	Level 1: 50% Level 2: 75%		
Wetlands[12]	40-55	VADCR	Level 1: 50% Level 2: 75%		

Notes

[1] Credit is for surface area of the rooftop is not considered impervious

[2] Credit is for surface area of pavers which are considered 50 to 90% imperviousness, depending on product

[3] This is a form of the permeable paver credit, at the low end of performance

[4] Credit is for all contributing impervious area which is excluded from total site impervious cover

[5] Non-rooftop disconnection to a filter strip is allowed as MDE credit but is not directly called out in the 10% guidance

[6] This MDE credit is specifically disallowed for the Critical Area 100 foot buffer, with a few exceptions

[7] There was no removal rate provided for this practice in the 2003 10% guidance manual

[8] Assumed to be comparable to rates for infiltration practices

[9] Assumed to be comparable to rates for bioretention practices

[10] Credit is for all contributing impervious area which is excluded from total site impervious cover, although parking lots are excluded

[11] Bio-swales are comparable to dry swales

[12] TP removal rates for multiple design variants are provided in Table 4.8 of the 10% Guide.

Note: that all pocket BMP options (pond, wetland and filter) have been dropped, as well as micro-pool ED, in the MD Critical Area.