STORMWATER BEST MANAGEMENT PRACTICES GREATER BALTIMORE SURVEY 2016

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PARTICPATING GROUPS

1000 Friends of Maryland • Alliance for the Chesapeake Bay
Baltimore Harbor Waterkeeper • Bird River Restoration Campaign
Blue Water Baltimore • Community & Environmental Defense Services
Center for Progressive Reform • Chesapeake Bay Foundation
Chesapeake Legal Alliance • Friends of Harford
Gunpowder RiverKeeper • Howard County Citizens Association
Howard County Sierra Club • Magothy River Association
Maryland Bass Federation Nation • North County Preservation
Severn River Association

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CONTENTS

I. SUMMARY.. 2

II. SURVEY PARTICIPANTS. 5

III. RECOMMENDATIONS. 6

IV. INTRODUCTION. 9

V. HOW WATERSHED DEVELOPMENT IMPACTS AQUATIC RESOURCES. 10

VI. STORMWATER MANAGEMENT 101. 13
The 2000 Maryland Stormwater Design Manual. 15
2009 Environmental Site Design.. 17

VII. STORMWATER BMP INSPECTION & MAINTENANCE. 19

VIII. GREATER BALTIMORE STORMWATER BMP SURVEY METHODS. 19
Selection of BMPs To Be Surveyed. 19
Ease of Evaluation. 20
BMPs To Be Surveyed. 20
BMP Selection Methodology. 22
Fixed Number of BMPs Per Jurisdiction & Type. 22
Assessment Methods. 23
Review of These Procedures. 24
How The BMPs Were Assessed. 24
Stormwater BMP Results Map. 25

IX. GENERAL RATING CRITERIA. 26
Good. 26
Maintenance Needed. 26
Failing. 27
Not Found. 27
Uncertain. 27

X. BMP-SPECIFIC RATING CRITERIA. 27
Pretreatment Measures. 27
Earth Embankments.. 28
Maintenance Needed. 28
Failing. 28
Bioretention, Micro-Bioretention & Rain Gardens. 29
Maintenance Needed. 29
Failing. 30
Infiltration Basin.. 30
Maintenance Needed. 30

Failing. . . . 30
Infiltration Trench. . . . 31
Maintenance Needed. . . . 31
Failing. . . . 31
Sand Filter. . . . 31
Maintenance Needed. . . . 32
Failing. . . . 32
Grass Channel, Dry or Bio Swales. . . . 33
Maintenance Needed. . . . 33
Failing. . . . 33
Wet Pond. . . . 33
Maintenance Needed. . . . 33
Failing. . . . 34

XI. FINDINGS. . . . 34
Percent of BMPs Found. . . . 34
Aquatic Resource Protection Condition. . . . 35
Indicators of BMP Failure. . . . 35
Drainage Area Issues. . . . 37
Slow BMP Drainage. . . . 37
Wetland Vegetation Present. . . . 37
Minimum Ponding Depth. . . . 38
Wet Pond Surface Area. . . . 38
Earth Embankment Issues. . . . 38
BMP Age & Failure Rates:. . . . 39
BMP Maintenance Issues. . . . 39
Bioretention, Micro-Bioretention & Rain Gardens. . . . 39
Infiltration Basins. . . . 42
Infiltration Trench. . . . 42
Sand Filter. . . . 42
Grass Channels, Dry & Bio Swales. . . . 42
Wet Pond. . . . 42
BMP Appearance Issues. . . . 43
Assessment Accuracy. . . . 43
Findings By Jurisdiction. . . . 44
How Stormwater Maintenance Is Handled By Each Jurisdiction. . . . 46
Anne Arundel County. . . . 46
Baltimore City. . . . 46
Baltimore County. . . . 46
Carroll County. . . . 47
Harford County. . . . 47
Howard County. . . . 48
Inspection & Maintenance Workload, Staffing & Enforcement Actions. . . . 48

Appendices. . . . 50

I. SUMMARY

Figure 1: Greater Baltimore Region

The Greater Baltimore Survey is a joint effort on the part of 17 local, statewide and national organizations and 119 volunteers. The goal is to provide Greater Baltimore region elected officials with the public support needed to achieve a high level of compliance with clean water laws. At this point, the Survey is focusing on three laws: construction site erosion control, stormwater Best Management Practice (BMP) maintenance, and compliance with Environmental Site Design (ESD) for new development and redevelopment.

For the first time in history we have the ability to gain the benefits of growth with no significant damage to aquatic resources, provided we achieve a high level of compliance with Environmental Site Design, BMP maintenance and construction site erosion control laws. Plus, achieving this goal will allow us to restore the hundreds of miles of Greater Baltimore waterways degraded by past development. Few actions would provide recreational and health benefits to as many people - especially those living in our most impoverished communities - as making the waters of Baltimore City and our older suburbs fit for wading, swimming, fishing, paddling or simply relaxing beside.

Majority of Stormwater BMPs Are In Good Condition, But A Fourth Are Failing

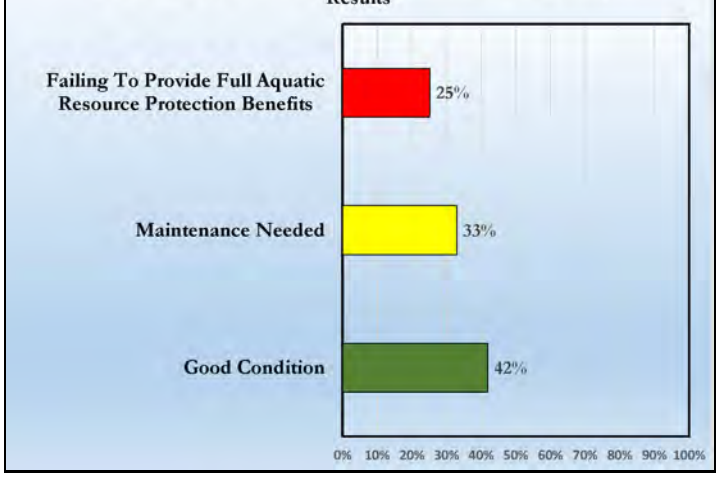
This report focuses on the more than 20,000 ponds and other stormwater Best Management Practices (BMPs) in the Greater Baltimore Region. This report presents the results of assessments of a sampling of these BMPs.

These BMPs could be keeping a tremendous amount of nutrients, sediment and other pollutants out of our waters. Ensuring that all BMPs are achieving these benefits is crucial to restoring thousands of miles of degraded waters in the region. Success will then set the stage for doing the same throughout the Chesapeake Bay watershed.

The Survey was carried out by 42 volunteers who made the stormwater BMP assessments in four-person Survey teams. Each team was accompanied by a Survey coordinator with extensive with stormwater BMP evaluation and maintenance experience. The volunteers were instructed in assessment procedures derived from guidance documents prepared by various stormwater management and inspection agencies.

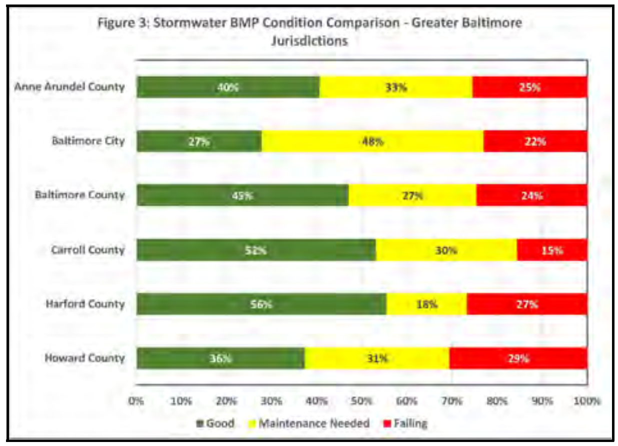
Survey volunteers found that while 42% of the BMPs appear to be in Good condition, another 25% are failing in ways that negate most aquatic resource protection benefits. The remaining 33% are in need of maintenance.

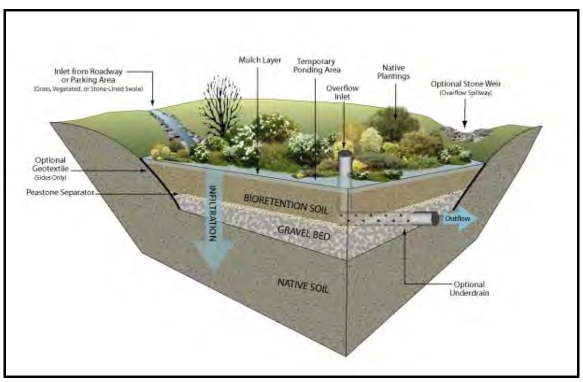
Figure 2: 2015 Greater Baltimore Stormwater BMP Survey Results



Survey Accuracy
With regard to the accuracy of this Survey, the six jurisdictions performed 7,047 stormwater BMP inspections based on the most recent annual reports available. Of these inspections, 32% resulted in the issuance of correction notices. Greater Baltimore Survey volunteers found that 25% of BMPs evaluated were Failing. Since Survey volunteers lacked the full access inspectors have, it is understandable that these local officials would find more failures. Nevertheless, the close agreement of these two values - 25% vs. 32% - attests to the accuracy of the evaluations performed by the Greater Baltimore Survey volunteers. A further indicator of accuracy was provided by Howard County stormwater officials who visited 118 BMPs assessed by Survey volunteers. The Howard County professionals found that 97% of the assessments made by Survey volunteers were correct.

No Jurisdiction Is Clearly Best or Worst
The graph to the right shows that of the six jurisdictions included in this Survey - Baltimore City and the counties of Anne Arundel, Baltimore, Carroll, Harford and Howard - no one jurisdiction is the best or worst. Some have a relatively low percentage of BMPs in Good condition but also a very low percentage of Failing facilities. Some are doing very well with regard to particular BMP categories. An attempt to rank the six jurisdictions would be difficult. However, it is clear that all six stormwater BMP inspection and maintenance programs need improvement and would benefit from greater public support.





A Typical Infiltrating BMP

The Most Effective BMPs Had The Lowest Failure Rate
With regard to the issues encountered, all BMPs but the Wet Pond depend upon infiltration of runoff through a filter bed or soil to remove pollutants and to achieve groundwater recharge. While some of the filtering BMPs[1] are designed with an underdrain system which precludes recharge, pollutant removal is still dependent upon infiltration through the filter bed. Infiltration failure was the most common issue negating aquatic resource protection for five BMP categories. Infiltration Basins exhibited the highest failure rate followed by Sand Filters. However, Carroll and Harford county have a high success rate when it comes to keeping infiltration basins in good working order, which may be

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[1] For the purposes of this report, filtering BMPs include bioretention, micro-bioretention, rain gardens, sand filters and dry or bio swales.

attributable to the design required by both jurisdiction plus regular maintenance. Bioretention, Micro-Bioretention and Rain Gardens had the lowest failure rate.

Half of Wet Ponds Required Sediment Removal
A loss of surface area was the most common Wet Pond issue. Pollutant removal efficiency within a Wet Pond is directly related to volume. As sediment and wetland vegetation accumulates within a pond, volume declines and so does pollutant removal along with aquatic resource protection benefits. Almost half (47%) the Wet Ponds had lost 50% or more of the original surface area. Wet Ponds should be cleaned when more than 10% of the original surface area is lost.

96% Of BMPs Maintained Voluntarily
There are about 20,000 existing BMPs in the Greater Baltimore region. Of these, 20% are maintained by the local government. The other 16,000 or so are maintained by the owner of the property on which each is located, by a homeowners association or some other entity or institution. As mentioned previously, 32% of inspections document issues requiring correction. Voluntary correction then occurs 96% of the time. Enforcement action is only required 4% of the time. It is rare that more draconian actions are needed, such as dragging an owner into court.

An Online Map With BMP Location, Findings & Photos
The results of each BMP evaluation were posted to a map which can be viewed online at: ceds.org/bmpmap. When the map appears click on the green, yellow or red map symbols to see a photo of the BMP along with the date assessed and a brief description of its condition. A list of the volunteers who made this Survey possible will be found on the next page.

II. SURVEY PARTICIPANTS
2015 GREATER BALTIMORE STORMWATER BMP SURVEY

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III. RECOMMENDATIONS

1. The six jurisdictions must continue to ensure that their staff is sufficient to inspect existing BMPs at least once every three years.

For the Maryland Department of the Environment (MDE)

2. The 2000 and 2009 *Maryland Stormwater Design Manual* should be updated with specific triggers for maintenance items such as:

   a. Minimum ponding depths that trigger the need to restore the facility to the original ponding depth for:

      i. F-1 Surface Sand Filter
      ii. F-2 Underground Sand Filter
      iii. F-3 Perimeter Sand Filter
      iv. F-4 Organic Filter
      v. F-5 Pocket Sand Filter
      vi. F-6 Bioretention
      vii. I-2 Infiltration Basin
      viii. M-3 Landscape Infiltration
      ix. M-4 Infiltration Berms
      x. M-5 Dry Wells
      xi. M-6 Micro-Bioretention
      xii. M-7 Rain Gardens
      xiii. M-8 Swales
      xiv. M-9 Enhanced Filters
      xv. O-1 Dry Swale

   b. Specify the percentage of original wet pool surface area that may be lost before it must be restored to the original volume.

   c. Provide additional guidance on the conditions under which Bioretention (F-6), Micro-Bioretention (M-6), Rain Gardens (M-7) and other BMPs may use wood mulch, mown grass or stone to cover the filter bed.

3. A small number of BMPs were found on MS4 lists that do not receive runoff from land uses normally considered in the context of stormwater management, such as landfills. The Maryland Department of the Environment should clarify whether these areas should be included in MS4 lists.

4. The MDE *StormwaterPrint* website[2] allows the public to determine what BMPs serve their home and watershed. At a minimum, this website should be expanded to provide the information shown on the GBS BMP Map[3]:

   a. Date of last inspection,
   b. BMP condition;
   c. Problems found; and
   d. Photo(s).

For MDE & Local Jurisdictions

5. Annual Municipal Separate Storm Sewer Systems reports should contain:

   a. The data presented in Table 8 and Table 9, in this report;

   b. A statement to the effect that the funds needed to inspect each BMP every three years will be allocated;

   c. A description of inspection priorities and enforcement procedures similar to that presented in the Anne Arundel County report;

   d. The detailed analysis of stormwater BMP effects upon pollutant loads like that presented in the Baltimore County report;

   e. A detailed description of the inspection process and findings such as that contained in the Carroll and Harford County reports;

   f. A rating system similar to that used by Harford County and a breakdown of BMP condition based upon this system; and

   g. The Howard County report referenced a tracking system which may be of value to other jurisdictions. The Howard report also mentioned some of the difficulties involved in achieving compliance. It would help if further detail could be provided in future reports. The other five jurisdictions should do the same.

6. Local jurisdictions should consider using simplified assessment procedures to quickly screen BMPs for maintenance needs. Simplified procedures are presented in *Bioretention Illustrated:*

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[2] See *StormwaterPrint* at: http://www.mde.state.md.us/programs/Water/StormwaterManagementProgram/stormprint/Pages/index.aspx

[3] The GBS BMP Map can be viewed at: http://ceds.org/bmpmap.htm

A Visual Guide for Constructing, Inspecting, Maintaining and Verifying the Practice[4]. Simplified procedures for other BMPs are given in the factsheets in Attachment A of this report.

7. There would be value in researching why Carroll and Harford Counties are particularly successful in keeping Infiltration Basins and Trenches in Good condition.

8. Finally, keeping BMPs free of trash and attractively landscaped is key to public acceptance.

For Future Greater Baltimore Surveys

9. Underground and Perimeter Sand Filters (F-2 and F-3) should not be included in future Greater Baltimore Surveys.

10. Rain Gardens located on private residential lots should not be included in future Greater Baltimore Surveys unless volunteers have the time to call ahead and make an appointment.

11. Given the abundance of extended detention ponds and the role they play in pollutant retention, these BMPs should be included in future surveys.

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[4] Available online at: http://chesapeakestormwater.net/2013/04/technical-bulletin-no-10-bioretention-illustrated-a-visual-guide-for-constructing-inspecting-maintaining-and-verifying-the-bioretention-practice/

IV. INTRODUCTION

The Greater Baltimore Survey is a joint effort of 17 local, statewide and national organizations. The purpose of the Survey is to determine how successful six jurisdictions have been in achieving compliance with key clean water laws. The six jurisdictions are Baltimore City and the five surrounding counties - Anne Arundel, Baltimore, Carroll, Harford and Howard. If compliance was found to be low then the groups participating in the survey would seek to provide the public support needed to improve compliance.

The first survey was conducted in June, 2014 and focused on construction site erosion control. This survey was carried out by 33 volunteers who assessed compliance with erosion control laws on 105 construction sites spread throughout the six jurisdictions. The June 2014 study documented an erosion control compliance rate of 23%. The reason why we focused on erosion control is that covering exposed soil with straw mulch and grass is far more effective in preventing construction site mud pollution when compared to the black silt fence and small ponds found along the edge of most sites.

The second survey was carried out in June, 2015 by 39 volunteers who assessed 131 sites. They found that erosion control compliance had risen from 23% a year earlier to 37% - an improvement of 61%. Though 37% is far short of our goal of 100%, the dramatic improvement is nevertheless heartening. It is clear to the participating groups that the public attention and support generated by the Greater Baltimore Survey was a key factor in achieving this dramatic improvement in control quality.

The number of people living in the Chesapeake Bay watershed increases by nearly 1% per year.[5] New construction activity may keep 87,000 acres of the watershed disturbed each year. This makes development arguably the *only source of Bay pollution that is increasing annually*. Construction phase sediment releases is the first of two pollution sources associated with new development and redevelopment. The second is post-construction stormwater runoff from rooftops, streets, parking lots and other *impervious* surfaces.

Since 1980, more than 100,000 stormwater ponds and other Best Management Practices (BMPs) have been built throughout the Bay watershed to control flooding and capture runoff pollution. Over the last decade, the six Bay watershed states and the District of Columbia adopted new, more effective approaches to controlling stormwater pollution.

In Maryland, the more effective approach is known as *Environmental Site Design* (ESD). If construction site erosion control, stormwater BMP maintenance and ESD compliance all work well then the possibility exists that this source of Chesapeake Bay pollution will no longer increase; at least in the Greater Baltimore region and other localities where citizens actively support elected officials responsible for making these programs work..

This report focuses on Stormwater BMP Maintenance in the region. According to data provided by the six jurisdictions, more than 20,000 BMPs exist throughout the region. State law requires that the

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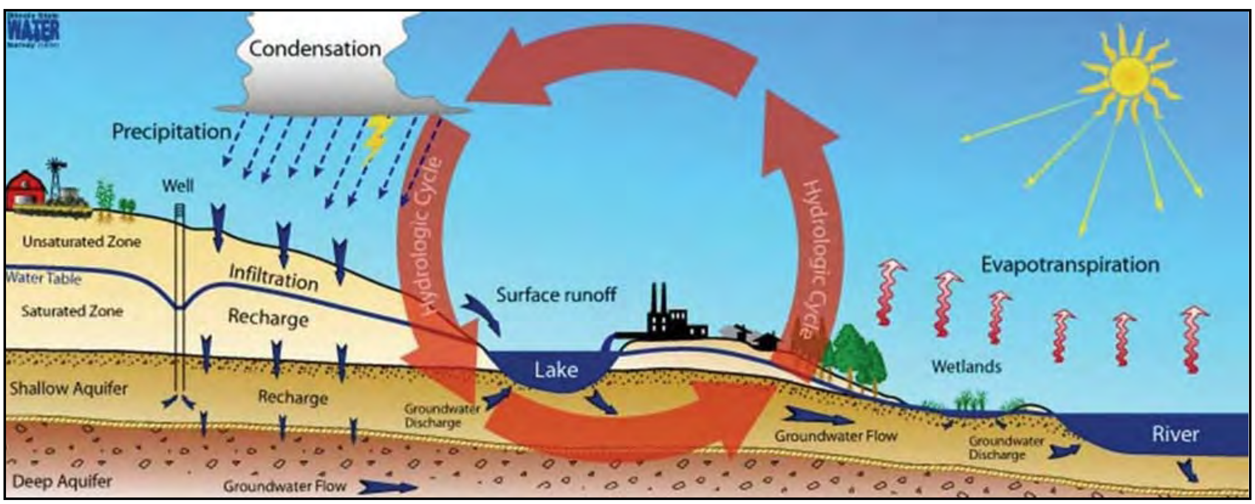
5 See: http://www.chesapeakebay.net/indicators/indicator/chesapeake_bay_watershed_population

local government ensure that each BMP be inspected for maintenance needs at least once every three years and ensure that maintenance is promptly carried out[6]. But stormwater BMPs are far less visible than schools, parks, and other government services. Because of the lack of visibility and public attention, stormwater budgets are vulnerable to cut-backs in tight times. A primary goal of the Survey is to shine a bright light on BMP maintenance to ensure that it is adequately funded and has the support of elected officials, which is essential to success.

V. HOW WATERSHED DEVELOPMENT IMPACTS AQUATIC RESOURCES

Converting forest and farms to houses, streets, shopping centers and parking lots can greatly increase the volume of stormwater runoff as well as the quantity of pollutants entrained in runoff. Most of the impact comes from sealing the earth with *impervious* surfacings: asphalt, concrete, rooftops, etc. It takes up to 1.5-inches of rain over a 24-hour period to cause runoff from a forest but just 0.2 inches generates runoff from an impervious surface. As a result, watershed development causes the frequency and severity of downstream flooding to increase dramatically. In fact, converting a forest-covered watershed to homes on ¼-acre lots can cause floodwater volumes to recur annually which were seen but once a century before development. This change threatens streamside homes, bridges and other structures. The increase in floodwater flows also causes extensive stream channel erosion. Typically a stream channel would be scoured two- to eight-fold wider once the watershed was intensively developed.[7]

The increase in runoff comes at the expense of groundwater recharge. An acre of Maryland forest typically absorbs about 250,000 gallons of precipitation per year and this water travels deep enough into the earth to recharge the groundwater system. As shown in the figure below, over a period of weeks to years this runoff travels beneath the earth to eventually emerge at a spring or seep where it



Groundwater Recharge illustration from http://www.esri.com/news/arcuser/0408/groundwater.html

[6] Code of Maryland Regulations 26.17.02.11: www.dsd.state.md.us/comar/comarhtml/26/26.17.02.11.htm

[7] See page 42 in CWP 2003. Impacts of Impervious Cover on Aquatic Systems. The Center for Watershed Protection, 8391 Main Street, Ellicott City, Maryland 21043. www.cwp.org Available online at: http://clear.uconn.edu/projects/tmdl/library/papers/Schueler_2003.pdf

becomes surface water again. It is this inflow that provides the water carried by a stream or river between storms. Recharge and inflow are crucial to maintaining the health of wetlands and tidal waterways. After passing so far through the earth this inflow has an average temperature of 55°F and is exceptionally clean. Covering portions of a watershed with impervious surfaces reduces recharge and inflow. Also, runoff from heated impervious surfaces can raise stream temperature abruptly by 13°F.[8]

A tremendous amount of pollution settles upon rooftops, parking lots and other impervious surfaces. The pollution originates at distant coal-fired power plants and other industrial smokestacks. A large portion also comes from the vehicles we drive and local power plants. Our pets contribute waste that washes off lawns along with the fertilizers and pesticides we apply. As a result, runoff from our homes, streets and lawns contain an enormous amount of pollution.

Beginning with a 1979 study[9], researchers have found a close relationship between the health of aquatic resources and the percent impervious area (IA) of a watershed:

- Brook trout are our most sensitive species and begin disappearing at 2% IA or about one house per 12 acres of watershed area;[10]

- Brown trout and highly-sensitive wetlands (bogs-fens) decline at around 4% IA or one house per eight acres;[11]

- Tidal fish begin to decline above 5% IA with severe stress occurring above 17% IA;[12]

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[8] Nelson, Ka¨ren C., and Margaret A. Palmer, 2007. Stream Temperature Surges Under Urbanization and Climate Change: Data, Models, and Responses. Journal of the American Water Resources Association (JAWRA) 43(2):440-452. DOI: 10.1111 /j.1752-1688.2007.00034.x

[9] Klein, R.D., 1979. Urbanization and stream quality impairment. Water Resources Bulletin 15(4):948-963.

[10] Brook Trout: Strenko, S.A., R.H. Hildebrand, R.P. Morgan, M.W., Staley, A.J. Becker, A. Rosenberry-Lincoln, E.S. Perry and P.T. Jacobson. Brook Trout Declines with Land Cover and Temperature Changes in Maryland, North American Journal of Fisheries Management 28:1223–1232, 2008. Available online at: http://clear.uconn.edu/projects/tmdl/library/papers/stranko_etal_2008.pdf

[11] Brown Trout: CEDS analysis of Maryland Biological Stream Survey Data; Bogs: May, C. R. Horner, J. Karr, B. Mar, and E. Welch. 1997. Effects of Urbanization on Small Streams In the Puget Sound Lowland Ecoregion. Watershed Protection Techniques, 2(4): 483-494.

[12] James H. Uphoff Jr., Margaret McGinty, Rudolph Lukacovic, James Mowrer & Bruce Pyle (2011): Impervious Surface, Summer Dissolved Oxygen, and Fish Distribution in Chesapeake Bay Subestuaries: Linking Watershed Development, Habitat Conditions, and Fisheries Management, North American Journal of Fisheries Management, 31:3, 554-566. Available online at: http://dx.doi.org/10.1080/02755947.2011.598384

- Most other stream fish and wetlands begin declining above 8% IA;[13]

- Levels of disease-causing organisms appear to become sufficiently high that one should no longer wade or swim in a waterway draining a watershed with 15% IA[14]; and

- Most waters will be devoid of aquatic life at 25% IA.[15]

The green and brown areas on Figure 2, are watersheds containing nontidal streams and rivers which are rated High-Quality, Tier II waters by the Maryland Department of the Environment (MDE).[16] The tan colored watersheds may lose the high-quality status if any more pollution is released into the streams draining these lands. The green areas can still accommodated some additional impact. The High-Quality waters shown in Figure 2, are located on the outer edge of development. Much of this development had spread out from Baltimore City, mostly before the adoption of growth controls to reduce the intensity of rural sprawl.

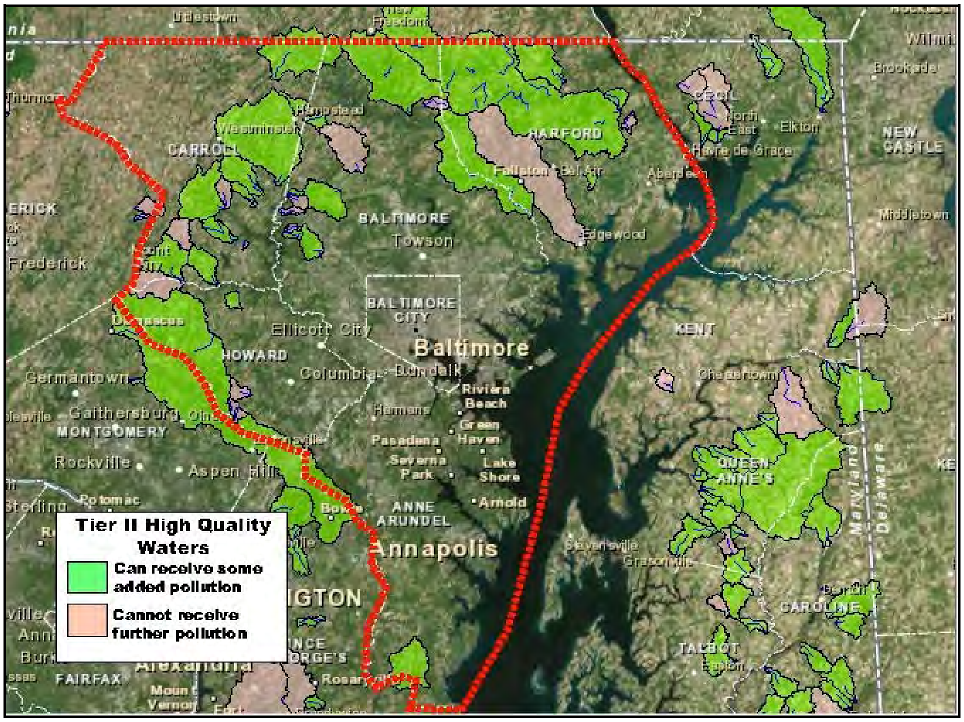

Figure 2: High-Quality Waters in the Greater Baltimore Region

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[13] Hicks, A.L. and J.S. Larson. 1996. The Impact of Urban Stormwater Runoff on Freshwater Wetlands and the Role of Aquatic Invertebrate Bioassessment. In: Effects of watershed development and management on aquatic ecosystems, Proceedings of an Engineering Foundation Conference, American Socof Civil Engineers, Snowbird, UT

[14] Mallin, M.A., K.E. Williams, E.C. Esham, and R.P. Lowe, 2000. Effect of human development on bacteriological water quality in coastal watersheds. Ecological Applications 10(4): 1047-1056.

[15] Klein, R.D., 1979. Urbanization and stream quality impairment. Water Resources Bulletin 15(4):948-963.

[16] See: http://www.mde.state.md.us/programs/Water/TMDL/Water%20Quality%20Standards/Pages/Antidegradation_Policy.aspx

There are a many high quality streams outside the green and brown Tier II watersheds shown in Figure 2. A number of these streams even support one of our most sensitive aquatic ecosystems a self-sustaining trout population. In fact, Baltimore County has as many trout streams as the rest of Maryland combined. The impervious cover in the High-Quality watersheds is generally 2% or less while the other good quality streams would be less than 5% impervious.

The waters nearest the vast majority of Greater Baltimore homes drain watersheds that are more than 15% impervious and are in poor condition. This means these waters are essentially unfit for most human uses. One would definitely not want to see a child playing in these waters. But all parents know it's impossible to keep kids out of these waters. Therefore, our only option is to restore each waterway to a healthful condition. And this is the ultimate goal of the Greater Baltimore Survey.

All of the tidal waters in the Greater Baltimore Region drain watersheds with an imperviousness greater than 5% and many are nearing 20% impervious. This means the fisheries of all our tidal rivers are stressed - some severely so - and contact with these waters maybe unhealthful, especially after major storms.

VI. STORMWATER MANAGEMENT 101

In the 1970s stormwater ponds began appearing in the more rapidly developing parts of Maryland. Dry ponds, like that pictured on the next page, would be installed to control downstream flooding. Since the ponds drained to the bottom following each runoff event no pollutants were stored and dry ponds had no effect on water quality.

Maryland enacted a statewide law requiring stormwater management on most development sites in 1982. Extended-detention ponds became very common *(see illustration on next page)*. At that time the focus was on controlling the flooding and stream channel erosion effects of watershed development. As explained in the box to the right, it was thought that both goals could be achieved by using ponds to store the post- and pre-development difference in runoff volume then by releasing the runoff at the same rate it left the site prior to development. In theory this approach would prevent downstream flooding and channel erosion. In reality it frequently did neither. Stormwater managers soon learned that it was not enough to just control the runoff rate.

Pond Design Example

During a storm recurring once every ten-years a 14-acre site might generate 344,080 gallons of runoff before being developed as 25 homes on half-acre lots. A ten-year storm would drop 5.1 inches of rain on the site during 24 hours. Before development a third of the rain would become runoff. After development half would runoff. The post-development project generates 748,000 gallons of runoff during the ten-year storm.

A pond(s) would be installed to store the difference (748,000 - 344,080) 403,920 gallons of runoff. Before development the runoff from a ten-year storm would leave the site at a maximum rate of 374 gallons per second (gps) then 928 gps afterward. The outlet of the pond would be designed to release runoff at a rate no greater than 348 gps. To put this in a familiar context, 348 gps is more than 9,000 time the flow rate from a kitchen sink.

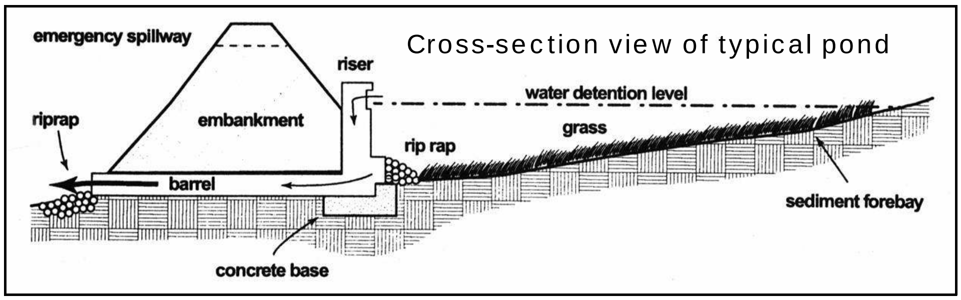
IDENTIFYING STORMWATER PONDLIKE BMP TYPES

Wet Pond (WP) Always holds water

Extended Detention Structure Wet (EDSW) holds permanent pool but dewatering device next to concrete spillway allows slow release of floodflows

Extended Detention Structure Dry (EDSD) retains runoff up to 72 hrs; Inside gravel dewatering device is a perforated pipe that slows the release of runoff from the pond

Two examples of Dry Pond (DP) which drains very quickly once runoff ceases



Observation Well

Infiltration basins must hold runoff until it can soak into the sandy soils of the basin floor so the spillway usually lacks an opening until a foot or two above the floor.

Infiltration Basin (IB) Observation well usually present; holds no water during dry weather; gravel trench may be present; runoff must pond a foot or two before first opening in spillway.

Here's the problem.

The channel erosion dilemma is the easiest to explain. Development would double to quadruple the volume of runoff during the storms responsible for eroding downstream channels. So the excess runoff is stored then released at the same rate that caused erosion before development. However, after development you're releasing two- to four-times as much runoff at the erosive rate. This exposed the channel to the erosive velocity for two- to four-times longer than prior to development. The net result is more bank and bed scouring-erosion.

The pond approach kept channels full or partially full of floodwaters for a longer period of time. Depending upon where a pond was located in a watershed it could actually cause floodwaters to reach higher elevations after development. The lesson learned by stormwater managers was that its not enough to control the rate at which runoff flows from a development site, but the volume must be managed too. Ponds cannot control volume; they can only store runoff temporarily. Instead measures were needed that managed volume in the same way as nature - by infiltrating rainfall into the soil. These revelations led to the adoption of the first *Maryland Stormwater Design Manual* in the year 2000.[17]

The 2000 Maryland Stormwater Design Manual

The 2000 manual set forth three criteria which all proposed development projects must meet: Water Quality Volume (WQ_V), Groundwater Recharge Volume (Re_V) and Channel Protection Volume (Cp_V).

To protect Water Quality the WQ_V was set at the first inch of runoff from proposed impervious surfaces. The WQ_V must be treated in a BMP capable of removing at least 80% of the solids suspended in runoff. About 90% of all the stormwater flowing from an impervious area over a period of decades is accounted for in the first inch of runoff. On average a storm generating an inch of runoff from impervious surfaces recurs monthly in Maryland.

Groundwater recharge is achieved by installing measures that infiltrate the first 0.07- to 0.38-inches of runoff into the soil. The actual rate varies with soil type. These Re_V are sufficient to maintain dry-weather stream flows at the same level that occurred prior to development. Infiltrating BMPs are pictured on the next page.

The Cp_V is the runoff volume generated by a storm recurring on average once a year. By managing the one-year storm it was thought that all the storms responsible for channel erosion would also be managed effectively. The one-year rainfall depth averages about 2.6 inches in 24 hours. To complywith the year 2000 manual meant mostly capturing the Cp_V in a pond. But instead of sizing the outlet to release the stored runoff at the predevelopment rate, the release would be set at a fraction of the predevelopment rate. It was thought that this approach would resolve the negative impact of ponds on channel erosion and prevent scouring of post-development channels. Only time will tell whether this assumption was correct.

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[17] See: http://www.mde.state.md.us/programs/water/stormwatermanagementprogram/marylandstormwater designmanual/Pages/Programs/WaterPrograms/SedimentandStormwater/stormwater_design/index.aspx

IDENTIFYING FILTER TYPE STORMWATER BMPS

Bioretention (BR) Micro-Bioretention (ESDMB) or Rain Garden (ESDRG): Usually has storm drain inlet with openings one foot above mulched or grass surface; observation well usually present.

Infiltration Trench (IT) Stone or gravel usually exposed at surface often with observation well

Observation Wells

Swale (SW) usually has a wide bottom; observation well maybe present

Though the floor of sand filters is supposed to be grass the sand is frequently visible

Sand Filter (SF) sometimes have numerous plastic caps present, which may be clean-outs or (if single) an observation well

The 2000 manual contained two other criteria: Overbank Flood Protection and Extreme Flood. The Overbank Flood addresses the ten-year storm and the Extreme Flood recurs once every 100 years. Both are only required when a review agency determines that a project may increase floodwaters in a way that could cause damage to downstream buildings, bridges or other structures. But Extreme Flood control may be required for all development in the watersheds of:

- Carroll Creek in Frederick City and Frederick County;
- Gwynns Falls in Baltimore City and Baltimore County; and
- Jones Falls in Baltimore City and Baltimore County.[18]

2009 Environmental Site Design

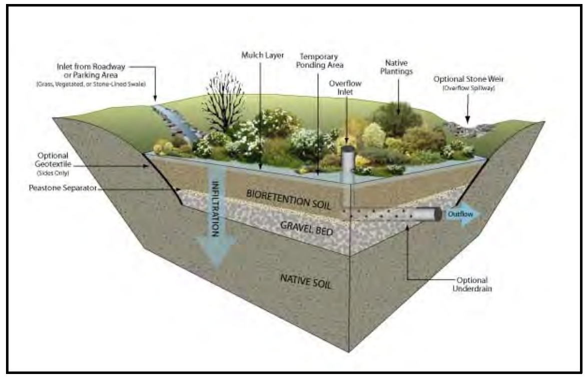
In 2009, Maryland adopted a new approach to stormwater management known as *Environmental Site Design* (ESD). With ESD the goal is to concentrate impervious surfaces on that portion of a site underlain by the permeable soils suitable for highly-effective infiltration practices. Though greater emphasis was placed on avoiding sensitive areas like stream and wetland buffers, steep slopes and highly-erodible soils and forest, ESD did not impose actual restrictions other than those already in existence. The big changes brought about by ESD was the use of 15 highly-effective BMPs. These BMPs were limited to much smaller drainage areas than those shown in the 2000 manual. The smaller drainage area should result in a lower failure rate.

Many of these BMPs provided recharge and can remove 80% to 95% of the nutrients and solids from runoff, making them far more effective than the previous BMPs. Also, most of the BMPs were designed so problems would occur on the surface where they are easiest to correct. The only other major change was that prior to ESD, designers had to provide one set of facilities to meet channel protection requirements and another set to meet Water Quality Volume and Recharge Volume. With ESD designers get credit towards all three requirements in each facility. As a result ponds are far less common on ESD sites though the smaller drainage areas result in a tripling in the number of BMPs per site.

It is hoped that ESD will result in BMPs that are easier to maintain while virtually eliminating the negative effects of watershed development. But the big unknown is how we're going to inspect an ever increasing number of BMPs much less keep them maintained. It is our hope that this Survey will help provide inspection agencies with the resources and political support needed to succeed at this Herculean task.

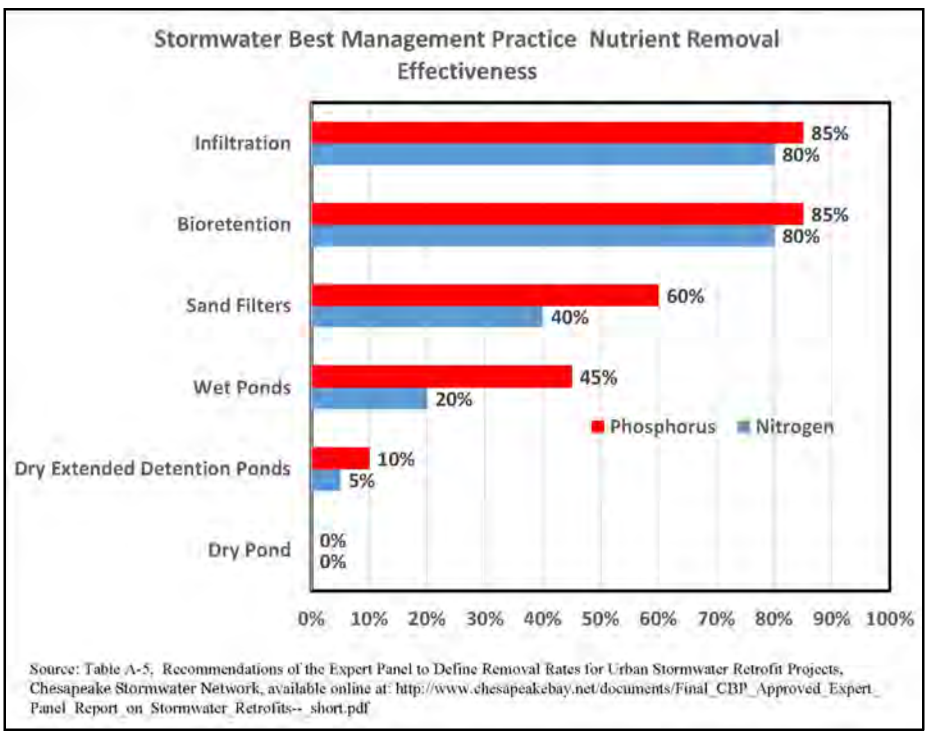
[18] See COMAR 26.17.02.07A at: http://www.dsd.state.md.us/comar/comarhtml/26/26.17.02.07.htm

Pictured to the right is a cross-section of a typical ESD practice. It is constructed by excavating a pit three- to five-feet deep in permeable soils. Gravel is placed on the bottom and a pipe underdrain may be connected to a nearby storm drain inlet (though the pipe would be capped most of the time). Three to four feet of a sand-organic matter mix (planting soil) is placed on top of the stone. The surface is either planted in grass or covered with two- to three-inches of hardwood mulch. The surface is also depressed six- to twelve-inches below the point where runoff could flow out of the BMP. The surface area of the facility is sized to store the first inch of runoff from impervious surfaces in the six- to twelve-inch depression or "ponding" area. After runoff infiltrates down through the bioretention soil (sand-organic matter) layer, 80% to 95% of nutrients and solids are removed. The treated runoff is then released into underlying soils to provide groundwater recharge. Since the entire one-year storm runoff volume flows through the filter bed, downstream channel erosion in prevented along with a significant portion of floodwaters.



A Typical Micro-Bioretention Facility

With most ESD practices all three criteria are met with just one facility: Groundwater Recharge, Water Quality Volume and Channel Protection Volume. In most cases there's no need for ponds or other BMPs to augment an ESD practices. However, some ESD practices like the Green Roof do need to drain to other measures. While a Green Roof can remove pollutants entrained in rainwater it cannot meet recharge requirements. To do this the runoff treated by the Green Roof must then flow to another BMP like Micro-Bioretention. The graph to the right compares the effectiveness of all BMP categories with regard to nutrient removal.



VII. STORMWATER BMP INSPECTION & MAINTENANCE

In Maryland one must obtain a grading permit before a development project can begin. The permit is required for projects disturbing more than 5,000 square feet. To get the permit the applicant must receive approval from the local jurisdiction for a stormwater management plan as well as an erosion and sediment control plan. The reviewing agency must find that the plan fully conforms to the 2000-2009 *Maryland Stormwater Design* manual along with any additional requirements imposed by the local jurisdiction. The applicant must also sign an agreement to allow inspections of the facility. The agreement binds current and future property owners to maintaining all the BMPs on the site in accordance with the stormwater management plan.[19]

Each of the six Greater Baltimore jurisdictions is required to ensure that every BMP is inspected at least once every three years for maintenance needs.[20] A portion of the BMPs in each jurisdiction are publicly maintained. These BMPs usually receive runoff from public streets or other publicly-owned property. Most BMPs must be maintained by the owner of the land on which each is located.

Many local jurisdictions send a letter to a BMP owner alerting them that the facility will soon be inspected. Once completed the owner will receive a copy of an inspection report detailing the findings. If deficiencies are found that require maintenance then the owner may receive a correction notice. This notice will specify the items to be corrected and give a due date. If the inspector finds corrections are not made by the due date then a notice of violation may be issued. Failure to comply with the violation notice could result in a fine and/or the owner being required to appear before a judge. The vast majority of BMP owners make the required corrections. Legal action is rarely needed.

VIII. GREATER BALTIMORE STORMWATER BMP SURVEY METHODS

The purpose of the Stormwater BMP Survey is to provide an independent assessment of how well our most effective stormwater Best Management Practices (BMPs) are being maintained in the Greater Baltimore region: Baltimore City and the counties of Anne Arundel, Baltimore, Carroll, Harford and Howard. Past local surveys have revealed up to a 50% failure rate due to poor BMP maintenance[21]. If the regionwide survey shows that a significant percentage of BMPs are failing, then the groups participating in the survey will seek to provide the public support elected officials need to achieve the full aquatic resource protection benefits these measures can attain.

Selection of BMPs To Be Surveyed

All six jurisdictions are required to submit an annual *Municipal Separate Storm Sewer System* (MS4)[22] report to the Maryland Department of the Environment (MDE). Each report contains an appendix

[19] To see an example of an I&M Agreement: http://www.aacounty.org/IP/Resources/inspection andmaintenanceagreement.pdf

[20] See COMAR 26.17.02.11A http://www.dsd.state.md.us/comar/comarhtml/26/26.17.02.11.htm

[21] See the Watershed Audits posted at: ceds.org/audit

[22] See: http://www.mde.state.md.us/programs/water/stormwatermanagementprogram/pages/programs/water programs/sedimentandstormwater/storm_gen_permit.aspx

listing all existing stormwater BMPs within their boundaries. These appendices were obtained from all six jurisdictions. An Excel file was created containing data from all six jurisdictions. About 1,500 BMPs were deleted because the databases indicated they had been approved but not yet built. After this initial culling, Table 1 on the next page, shows that the six databases contained a population of 20,300 BMPs. The BMPs are listed in Table 1, by: code, name, effectiveness, ease of evaluation, total number in all six jurisdictions and percent of total by code-name.

BMP Effectiveness

Effectiveness is based upon Table 2, in *Recommendations of the Expert Panel to Define Removal Rates for Urban Stormwater Retrofit Projects*, published by the Chesapeake Stormwater Network, on October 9, 2012[23]. Those BMPs listed as Runoff Reduction (RR) practices were considered highly-effective because of a high pollutant removal rate and groundwater recharge benefits. Stormwater Treatment (ST) BMPs are moderately effective due to a lack of groundwater recharge and generally lower pollutant removal rates. All other practices were considered Low with regard to effectiveness.

Ease of Evaluation

The volunteers who carried out this survey viewed each BMP from nearby public areas. Their assessments were based upon what they can see without removing observation well caps, lifting manhole covers, or entering a BMP to make measurements. A BMP is considered Easy to evaluate if key components are visible at the ground surface and the BMP is usually located in or adjacent to public areas. Also, the visible components must provide a strong indication of how well the facility is functioning. For example, Underground BMPs are Difficult to evaluate while Bioretention is Easy. Dry Wells are usually located next to buildings and away from public areas making them Difficult to assess.

BMPs To Be Surveyed

The Greater Baltimore Survey focused on the eight most common BMPs which are Highly- to Moderately-Effective and Easy to evaluate. These eight BMPs are highlighted yellow in Table 1 and are:

- Bioretention;
- Micro-Bioretention;
- Rain Gardens;
- Swales (Grass Channels, Dry and Bio Swales);
- Infiltration Basins;
- Infiltration Trenches;
- Sand Filters; and
- Wet Ponds.

There are 9,310 of these eight BMPs in the region. These eight BMPs account for 46% of all Greater Baltimore BMPs.

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[23] See: http://www.chesapeakebay.net/documents/Final_CBP_Approved_Expert_Panel_Report_on_Stormwater_Retrofits--_short.pdf

Table 1: Greater Baltimore Region Existing Stormwater Best Management Practices By FREQUENCY

Highlighted BMPs = 9,368

Code	Name	Effectiveness	Ease Of Evaluation	Total	Percent of Total
IT	Infiltration Trench	High	Easy	4,531	22.26%
DW	Dry Well	High	Difficult	3,070	15.08%
SF	Sand Filter	Moderate	Easy	1,548	7.60%
DP	Dry Pond	Low	Easy	1,536	7.54%
EDSD	Extended Detention Structure Dry	Low	Easy	1,213	5.96%
ED	Extended Detention	Low	Easy	1,139	5.59%
BR	Bioretention	High	Easy	831	4.08%
EDSW	Extended Detention Structure Wet	Low	Easy	830	4.08%
WP	Wet Pond	Moderate	Easy	639	3.14%
ESDRG	ESD Rain Garden	High	Easy	582	2.86%
UGS	Underground storage	Low	Difficult	577	2.83%
IB	Infiltration Basin	High	Easy	484	2.38%
SW	Swale	High	Easy	466	2.29%
SC	Stormceptor	Low	Difficult	396	1.95%
SM	Shallow Marsh	Low	Easy	349	1.71%
OGS	Oil-Grit Separator	Low	Difficult	289	1.42%
ESDMB	ESD Micro-Bioretention	High	Easy	287	1.41%
ESDRTD	ESD Rooftop Disconnection	Moderate	Easy	280	1.38%
ESD	Environment Site Design	High		238	1.17%
O	Other			219	1.08%
ESDSFNAC	ESD Sheet Flow Conservation Areas	High	Easy	119	0.58%
UGSF	Underground Sand Filter	Moderate	Difficult	77	0.38%
PP	Porous Pavement	High	Difficult	75	0.37%
BS	Baysaver	Low	Difficult	73	0.36%
LS	Level Spreader	Low	Easy	65	0.32%
ESDRH	ESD Rainwater Harvesting	High	Difficult	52	0.26%
ESDRH	Rainwater Harvesting	High	Difficult	52	0.26%
ESDNRTD	ESD NonRooftop Disconnection?	Moderate	Easy	50	0.25%
ESDSW	ESD Swale	High	Easy	48	0.24%
ESDDW	ESD Dry Well	High	Difficult	36	0.18%
STORMFILTER	Stormfilter	Low	Difficult	35	0.17%
CD	Check Dam	Low	Easy	31	0.15%
ESDIL	ESD Landscape Infiltration?	High	Easy	29	0.14%
ESDEF	Enhanced Filters	High	Difficult	28	0.14%
ESDPERM	ESD Permeable Pavers	High	Difficult	23	0.11%
GS	Grassed Swale	Low	Easy	14	0.07%
ESDSGW	ESD Submerged Gravel Wetland	High	Difficult	12	0.06%
FOREBAY	Forebay	Low	Easy	11	0.05%
ESDIB	ESD Infiltration Berm	High	Easy	9	0.04%
BIO	Bioretention Pond	?	Easy	7	0.03%
ESDGR	ESD Green Roof?	Moderate	Difficult	4	0.02%
FILTERRA	Filterra	High	Difficult	2	0.01%
VB	Vegetated Buffer	Low	Easy	2	0.01%
		TOTAL		20,358	

BMP Selection Methodology
The model for this survey is a report entitled *Stormwater BMPs in Virginia's James River Basin: An Assessment of Field Conditions & Programs*, published by the Center for Watershed Protection (CWP), in June 2009. The CWP report covered eight Virginia jurisdictions (4 cities; 4 counties) and the Greater Baltimore Stormwater BMP Survey (GBS) covered six (1 city; 5 counties). The CWP database contained a bit more than 5,000 BMPs, while the GBS database has 9,310 BMPs. CWP set a goal of evaluating about 250 or 5% of the BMPs but only 3.6% actually were assessed. Since the GBS sample population is about twice as large, our goal was to evaluate 500 BMPs, with a minimum of 335 (3.6%).

CWP used the Microsoft Excel random number generator to select BMPs to be evaluated from the population. This same application was used to select the BMPs slated for assessment in the Greater Baltimore region. Additionally, another 100 were selected to account for BMPs which cannot be surveyed because they could not be found, were of the wrong type or were not visible from public areas. This brought the number of Greater Baltimore BMPs selected for assessment to 600.

Fixed Number of BMPs Per Jurisdiction & Type
The BMP population is dominated by Anne Arundel County Infiltration Trenches. Because of this our goal was to randomly select a fixed number of BMPs of each type for each jurisdiction. The amount of this fixed number was selected using the equation: 600 BMPs ÷ 8 types ÷ 6 jurisdictions = 12.5 BMPs per type/jurisdiction or 100 per city or county. If there were less than 12 BMPs of a given type in a jurisdiction, then all of those were selected for assessment. Table 2 shows the total number of each BMP type by jurisdiction and the number selected for assessment.

Table 2: Greater Baltimore Region Stormwater BMPs To Be Assessed

		NUMBER OF BMPs BY TYPE						
Code	Name	Anne Arundel	Baltimore City	Baltimore County	Carroll	Harford	Howard	Total
IT	Infiltration Trench	3,599	21	247	266	54	344	4,531
	Number To Be Assessed	13	12	13	12	13	12	75
SF	Sand Filter	271	134	840	144	84	75	1,548
	Number To Be Assessed	12	13	12	13	12	13	75
BR	Bioretention	387	35	173	1	10	225	831
	Number To Be Assessed	16	16	16	1	10	16	75
WP	Wet Pond	199	18	130	0	50	242	639
	Number To Be Assessed	15	15	15	0	15	15	75
ESDRG	ESD Rain Garden	167	8	9	3	0	395	582
	Number To Be Assessed	27	8	9	3	0	28	75
IB	Infiltration Basin	155	9	101	122	23	74	484
	Number To Be Assessed	14	9	13	13	13	13	75
SW	Swale	190	48	135	2	8	83	466
	Number To Be Assessed	17	16	16	2	8	16	75
ESDMB	ESD Micro-Bioretention	46	32	93	1	0	115	287
	Number To Be Assessed	18	18	19	1	0	19	75
	Total	**5,014**	**394**	**1,822**	**583**	**300**	**1,666**	9,779
	Number To Be Assessed	**132**	**107**	**113**	**45**	**71**	**132**	600

Table 2, shows that the actual number of BMPs per jurisdiction targeted for assessment was not exactly 100 but ranged from 45 to 132. This is due to a paucity of certain BMP types in most of the jurisdictions. As a result, the pooled data for all six jurisdictions would be the most meaningful. Or put another way, the data is probably not adequate to compare the six jurisdictions with regard to their success in maintaining specific BMP types.

Assessment Methods

The assessment methods are based upon more than four decades of experience managing volunteers in gathering aquatic resource protection data. The author of these methods and this report, CEDS president Richard Klein, had previously published:

- Auditing Chesapeake Bay Watershed Stormwater Best Management Practices;[24]
- 20-Minute YouTube Presentation on Locating & Evaluating Stormwater BMPs;[25]
- Rain Garden Audit;[26]
- Severn River Audit[27]; and
- Corsica River Audit.[28]

The following publications were reviewed for additional assessment methods appropriate for a volunteer survey. These publications were:

- 2000 & 2009 *Maryland Stormwater Design Manual*, Maryland Department of the Environment;[29]
- *Stormwater BMPs in Virginia's James River Basin: An Assessment of Field Conditions & Programs, Center for Weatershed Protection;*[30]
- *Inspection Protocols for Maintaining and Verifying LID Practices*, Chesapeake Stormwater Network;[31]

[24] See: http://ceds.org/audit/ChesaBaySWMBMPAudit.pdf

[25] See: https://www.youtube.com/watch?v=_a9LAIXDr44

[26] See: http://ceds.org/raingarden.html

[27] See: http://ceds.org/audit/SevernRiverPWA_Report.pdf

[28] See: http://ceds.org/audit/CorsicaRiverPWA.pdf

[29] See: http://www.mde.state.md.us/programs/water/stormwatermanagementprogram/marylandstormwaterdesignmanual/Pages/Programs/WaterPrograms/SedimentandStormwater/stormwater_design/index.aspx

[30] See: http://www.chesapeakebay.net/channel_files/19219/cwp_james_river_tech_report_final_draft_062509.pdf.pdf

[31] See: http://chesapeakestormwater.net/2013/01/inspection-protocols-for-maintaining-and-verifying-the-performance-of-lid-practices-webcast/

- *Bioretention Illustrated: A Visual Guide for Constructing, Inspecting, Maintaining and Verifying the Bioretention Practice*, Chesapeake Stormwater Network;[32] and
- Montgomery County MD Department of Environmental Protection Stormwater Maintenance Program factsheets.[33]

Review of These Procedures
A request to comment on these procedures was sent to the:

- Anne Arundel County Environmental Programs & Infrastructure Inspections;
- Baltimore City Department of Public Works;
- Baltimore County Department of Environmental Protection & Sustainability;
- Carroll County Bureau of Resource Management;
- Harford County Division of Highways and Stormwater Management;
- Howard County Stormwater Management Division;
- Sediment & Stormwater Division, Maryland Department of the Environment;
- Chesapeake Stormwater Network;
- Maryland Stormwater Partners; and
- Center for Watershed Protection.

No comments were received.

How The BMPs Were Assessed
Four volunteers made up a Survey Team. Each survey lasted about three hours: 10:00 AM to 1:00 PM. Volunteers registered for specific surveys at: ceds.org/gbs2015. Surveys were conducted seven days a week for eight weeks. Volunteers were recruited from the organizations participating in this survey. Some had little experience with BMP evaluation while a few had advanced degrees or years of experience in this or related fields. The goal was to have a large number of potential volunteer leaders learn about the importance of stormwater BMPs, how they are maintained, why public support is crucial to good maintenance and how volunteers can mobilize this support in their city or county.

The eight BMPs have been grouped into the following six categories:

- Bioretention, Micro-Bioretention & Rain Gardens;
- Grass Channels, Dry & Bio Swales;
- Infiltration Basins;
- Infiltration Trenches;
- Sand Filters; and
- Wet Ponds.

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32 See: http://chesapeakestormwater.net/2013/04/technical-bulletin-no-10-bioretention-illustrated-a-visual-guide-for-constructing-inspecting-maintaining-and-verifying-the-bioretention-practice/

33 See: http://www.montgomerycountymd.gov/dep/water/stormwater-facilities.html

First, volunteers learned how to determine BMP type by looking at illustrations of each type *(see pages 9 and 11)*. A two-page assessment factsheet was drafted for each of the six BMP category *(see Attachment A)*. A seventh factsheet focuses on Forebays and other pretreatment measures designed to keep sediment from reaching a BMP. Flash Cards were provided that summarized key assessment points for each BMP category *(see Attachment B)*. Volunteers used a two-page checklist - a separate one for each category and each BMP - to record their findings *(see Attachment C)*. The first page of each checklist is identical. The second page poses questions to consider as one assesses each BMP category.

Prior to each survey, team members were asked to review the training package. At the start of each survey, the coordinator (Richard Klein) did a 15-minute review of the package contents. Each volunteer received a clipboard with checklists attached and a list of BMPs to be surveyed on that date. A list of BMPs was generated for each Survey. To minimize travel time these BMPs were in close proximity to one another and the meeting place.

At each BMP site the coordinator sought to park in a public area where team members could see all they needed to without getting out. The coordinator also urged volunteers to hop out and take a closer look if any desired to do so. Under no circumstances were volunteers allowed to enter onto private property. Again, all observations were made from adjacent or nearby public areas.

Team members were encouraged to discuss assessment factors with the goal of reaching consensus, though volunteers were free to note answers differing from that of other team members. The coordinator did not offer his opinion and only provided guidance when requested.

The coordinator usually had the most recent aerial photo available of each BMP along with the oldest in which the facility can be clearly seen. These photos aided the volunteers in assessing factors such as loss of pond surface area, degree of vegetation overgrowth, etc.

Stormwater BMP Results Map

Data for all BMPs was entered into an Excel file and posted on the Google Map at: ceds.org/bmpmap. While our goal was to assess 600 BMPs, the map has 632 BMP symbols. This is because we found unlisted BMPs or there were other BMPs directly connected to a target facility.

When you go to the map click on a symbol. You will then see the BMP ID, which ends with a letter. This letter and the one in each symbol identifies the BMP type as:

b	bioretention
f	sand filter
g	rain garden
i	infiltration basin
m	micro-bioretention
p	wet pond
s	swale
t	infiltration trench

The symbol colors have the following meaning:

- **Good:** BMP was found and assessed, no defects found that would lower aquatic resource protection benefits;
- **Maintenance Needed:** BMP was found and assessed, defects were found which would prevent the facility from providing full benefits;
- **Failing**: BMP assessed and found to be failing in a way that negates aquatic resource protection benefits; and
- **Not Found/Not Visible**: BMP not found or not visible from public areas or condition uncertain.

Volunteers kept their completed checklists. After the data was entered and uploaded, volunteers were provided with the Excel file and asked to compare it with their survey sheets to verify accuracy. They were also urged to check the updated map data for accuracy.

IX. GENERAL RATING CRITERIA

Five general ratings were used to represent the overall condition of each stormwater BMP.

Good

The BMP did not exhibit any problems that would have a negative effect on aquatic resource protection benefits. The survey was limited to problems that can be seen without examining observation wells, removing manhole covers or placing monitoring equipment within the facility. In other words, there could be problems we could not detect.

Maintenance Needed

The BMP exhibited problems that should have been corrected with ongoing maintenance, but the problems did not rise to the point of substantially affecting aquatic resource protection benefits. In other words, the BMP did not exhibit any of the conditions which would result in a rating of failing. There is one maintenance issue common to all six BMP categories:

> We noted the presence of any exposed soil or other erodible sediments within the area draining to a BMP as well as the facility side slopes. The entry of eroded soil into a BMP can quickly cause surface clogging which prevents infiltration facilities[34] from providing aquatic resource protection benefits. If any exposed soil was present within the drainage area then the BMP was rated "Maintenance Needed" and this issue was noted in the summary.

Some BMPs have observation wells or clean-outs. Both are supposed to be capped to prevent objects from being dropped into the pipe or other problems. If an observation well or clean-out was present but the cap was missing then this was noted as a Maintenance Needed item. This is an example of several maintenance issues which would have no immediate effect on aquatic resource protection benefits.

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[34] Infiltration BMPs include: Infiltration Basins, Infiltration Trenches, Sand Filters, Permeable Pavers, Reinforced Turf, Landscape Infiltration, Infiltration Berms, Dry Wells, Micro-Bioretention, Rain Gardens, Swales and Enhanced Filters.

Failing
Problems were found that substantially reduced the aquatic resource protection benefits normally provided by the BMP. The criteria for failing varied among the six BMP categories. But there is one failure criteria common to all six categories:

> **Runoff does not flow to the BMP.** Occasionally we found BMPs that were at a higher elevation than any nearby impervious surfaces. Or a gully had formed or some other feature was present that kept runoff from entering the BMP. If a BMP received no impervious surface runoff then it provided zero aquatic resource protection benefits and was rated as failing.

Not Found
For the most part, the coordinates provided by the six jurisdictions were extremely accurate. Many BMPs were with feet or even inches of the point identified with the coordinates. But a number of BMPs were not found at the coordinates and there was nothing in the vicinity which remotely resembled the BMP. Likely explanations for these missing BMPs include:

- the BMP was never built;
- the BMP had been removed;
- a structure was built over the BMP; or
- the coordinates were wrong.

Uncertain
This rating was assigned to BMPs that could not be seen from the nearest public areas, but may still be present. Many Rain Gardens fell into this category. Typically, Rain Gardens are installed downslope of a house with the only public area being a road frequently located upslope of the house. These Rain Gardens were seldom visible from the road because they were hidden by the house. We may do a sampling in the future by asking homeowners for permission to assess their Rain Garden.

X. BMP-SPECIFIC RATING CRITERIA

Six categories of BMPs were assessed through the Greater Baltimore Survey 2015. A BMP was rated Good if it did not exhibit any of the following Maintenance Needed or Failing characteristics. In addition, two features common to many BMPs were rated: Pretreatment Measures and Earth Embankments. Though data was recorded with regard to the appearance of a BMP, this information was not used in the rating; only those factors that would affect the ability of a facility to protect aquatic resources.

Pretreatment Measures
The Maryland Stormwater Design Manual[35] calls for structures to capture sediment before it reaches BMPs Pretreatment Measures. These measures generally belong to one of four types: Forebay, Pretreatment Sediment Chamber, Grass Filter Strip and a Gravel or Stone Diaphragm. Some BMPs

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[35] See: http://www.mde.state.md.us/programs/water/stormwatermanagementprogram/marylandstormwater designmanual/Pages/Programs/WaterPrograms/SedimentandStormwater/stormwater_design/index.aspx

benefit from multiple measures. Occasionally a Sand Filter or Bioretention facility would treat the first inch of runoff that would otherwise flow to a pond.

A BMP would not be flagged as Failing just because pretreatment measures required maintenance. However, a lack of timely maintenance may soon result in failure due to sediment movement into the portion of the BMP where aquatic resource protection benefits are provided. The following would result in pretreatment measures being designated as needing maintenance:

1. Sediment is getting through pretreatment measure to the portion of the BMP where aquatic resource protection benefits are provided.

2. Forebay is 50% or more full of sediment;

3. Forebay is so heavily overgrown with vegetation that it is difficult to tell how much storage capacity has been lost;

4. Grass filter strip is less than the minimum 20 feet;

5. Sediment covers more than 25% of filter strip length; or

6. Stone-gravel diaphragm interstices full of sediment and/or plants growing from interstices.

Earth Embankments
Infiltration Basins and Wet Ponds are frequently created by placing an earth embankment across a shallow valley. The following criteria were used to rate the condition of earth embankments.

Maintenance Needed: The following conditions could endanger the stability of the earth embankment, but may not constitute imminent danger.

1. Embankment is so heavily overgrown with herbaceous vegetation that you cannot see if any maintenance issues are present;

2. Animals have burrowed into the embankment; or

3. Trees or other woody vegetation (shrubs) are present on the embankment.

Failing: The following conditions could contribute to failure of an earth embankment during a major storm. These conditions are so serious that they would have been flagged as constituting Failure just so we'd be certain maintenance agency staff would be aware of the condition.

1. Low-spot along the top of the embankment, other than an emergency spillway. These low-spots could indicate differential settlement of the embankment and become a channel for floodwaters over-topping at this point rather than at the emergency spillway. Overtopping could lead to embankment erosion, then failure. Two ponds were found with low-spots. One had already washed out posing no further hazard. The other was a

very low dam posing little hazard. But both were referred to the local inspection agency; or

2. Presence of wet spots or wetland vegetation on the downstream face of a wet pond, which may indicate seepage (piping) through the embankment. This condition could result in washout of the embankment during a major flood.

Bioretention, Micro-Bioretention & Rain Gardens
All three of these BMPs use the same basic design. They differ mostly in maximum drainage area: Bioretention (F-6) = 5 acres, Micro-Bioretention (M-6) = 0.5 acres, and Rain Garden (M-7) = 0.05 acres.[36]

Maintenance Needed: This rating was assigned if a Bioretention, Micro-Bioretention or Rain Garden facility exhibited any of the following conditions:

1. The filter bed was so overgrown with weeds that one had difficulty finding the outlet, determining if mulch or sediment was present on the filter bed surface, or locating observation wells.

2. The Maryland Stormwater Design Manual calls for two- to three-inches of wood mulch on the filter bed surface. The mulch enhances pollutant removal and helps to maintain infiltration into the sand layer. But if the mulch is missing these three BMP designs can still provide aquatic resource protection benefits, albeit at a reduced level. Recently bioretention facilities have been designed with a mown grass cover, not mulch. However, a facility was flagged as "Maintenance Needed" if it had a mulch cover which is well past the point where the mulch should have been replaced. If a bioretention facility appears as though it was intended to have a grass cover and the grass cover was in good condition, then it was not flagged for maintenance. Some BMPs in this category had a covering of stone. Occasionally this is allowed in urban settings but the Manual should clarify the conditions where stone-only is permitted.

3. The Maryland Stormwater Design Manual also calls for six- to twelve-inches of ponding depth above the filter bed. But the manual does not provide a minimum depth. A Maryland Department of the Environment (MDE) engineer did state that some ponding depth must always be present since the weight of the ponded water serves to drive infiltration down through the mulch and sand layers.[37] However, the engineer could not provide a minimum depth and stated that this varies from one individually designed BMP to another. For the purposes of this survey we noted Maintenance Needed if the ponding depth was one- to three-inches. Occasionally we found that holes had been

[36] F-6, M-6 and M-7 refer to the code assigned to each of these three practices in the Maryland Stormwater Design Manual.

[37] Personal communication with Stewart Comstock, Maryland Sediment & Stormwater Program.

drilled in the side of a concrete outlet to prevent ponding. But this practice seems unique to Anne Arundel County.

Failing: This rating was assigned if a Bioretention, Micro-Bioretention or Rain Garden facility had any of the following conditions:

1. Water was present on the surface of the filter bed when 48 hours or more had elapsed since runoff from the last storm would have ceased entering the facility;

2. Wetland vegetation was present within the filter bed. To support wetland vegetation the upper six- to 18-inches of the filter bed must be saturated for at least two weeks during the growing season. The presence of wetland vegetation would therefore indicate that the filter bed was not draining completely within 48- to 72-hours. Cattails *(Typha sp.)* were the most common wetland vegetation encountered followed by the occasional appearance of Phragmites *(Phragmites australis)*; or

3. As stated above, there must be at least some ponding area above the filter bed to drive runoff down through the mulch and sand layers. If the depth was zero then the BMP was rated as Failing.

Infiltration Basin
These facilities may have both pretreatment measures and an earth embankment. The criteria for rating both are given above. Some Basins also have one or more Infiltration Trenches present on the floor. If Trenches were present then the criteria given in the next category (Infiltration Trench) was also applied to the Basin.

Maintenance Needed: This rating was assigned if an Infiltration Basin exhibited any of the following conditions:

1. The Maryland Stormwater Design Manual calls for keeping the floor and interior slopes of a Basin in grass. If the Basin floor is so overgrown with vegetation that one cannot assess the degree of sediment accumulation or tell if trenches-observation wells were present, then it was rated as Maintenance Needed.

2. Infiltration Basins are usually designed to store runoff up to a depth of a foot or two above the Basin floor. If the depth from the deepest spot on the floor to the first point where runoff could exit was less than three inches but more than zero, then the basin was rated Maintenance Needed.

Failing: This rating was assigned if an Infiltration Basin had any of the following conditions:

1. Water was present on the floor of the basin when 48 hours or more had elapsed since runoff from the last storm ceased entering the facility;

2. Wetland vegetation was present on the Basin floor; or

3. As stated above, there must be at least some ponding area above the Basin floor to drive runoff down through the floor of the infiltration basin. If the ponding depth was zero then the Basin was rated as Failing.

Infiltration Trench

As the name implies, an Infiltration Trench is usually a rectangular facility excavated anywhere from four to fourteen-feet below the ground surface. The Trench is filled with stone. The stone interstices (air spaces) account for 40% of the Trench volume which is where runoff is stored until it can infiltrate into adjacent and underlying soils. Trenches of two types were found: exposed stone and grass covered. Those with exposed stone could be evaluated more thoroughly.

Maintenance Needed: The Trench was rated Maintenance Needed if the stone interstices were visibly filled with sediment and/or there was vegetation growing throughout the stone surface indicating the interstices were full of sediment.

Failing: This rating was assigned if an Infiltration Trench had any of the following conditions:

1. For exposed stone trenches:

    a. Water was visible in the stone interstices when 48 hours or more had elapsed since runoff from the last storm would have ceased entering the facility; or

    b. Wetland vegetation was growing from the stone.

2. For Trenches covered by grass where it was obvious this was part of the design. Usually the grass would be mowed and an observation well or manhole cover would be present at the Trench location. If neither a well or manhole cover was present then the BMP was not assessed and was noted as *Not Found*. The Failing criteria for grass covered trenches was:

    a. The grass and surface soil was saturated when 48 hours or more had elapsed since runoff from the last storm would have ceased entering the facility; or

    b. Wetland vegetation was growing from the area where the trench was located.

    We did not encounter any grass-covered Trenches where either condition was present.

Sand Filter

In suburban and rural areas Sand Filters were of the above ground variety described in the Maryland Stormwater Design Manual as a Surface Sand Filter (F-1). In Baltimore City and other intensely developed areas the Sand Filters were mostly of the Underground (F-2) or Perimeter (F-3) type.

The Underground and Perimeter filters are actually both underground and require lifting manhole covers or heavy steel plates to evaluate. We tried using a borehole scope to make an evaluation but were hindered by a lack plans and maintenance criteria. Though we searched the internet extensively for both and even requested this information from manufacturers, we were unsuccessful.

Surface Sand Filters were easy to find and evaluate. Maintenance Needed and Failing criteria are provided below for the Surface Sand Filter only.

Maintenance Needed: This rating was assigned if a Sand Filter exhibited any of the following conditions:

1. The filter bed was so overgrown with weeds that one had difficulty: finding the outlet, determining if sediment was present on the filter bed surface, or locating observation wells.

2. The Maryland Stormwater Design Manual calls for mowing filter bed grass a minimum of three times per year. If grass is more than 12 inches tall then mowing is needed.;

3. The Maryland Stormwater Design Manual does not specify a minimum depth above the filter bed, though Figure 3.12 does show ponding above the bed. A Maryland Department of the Environment (MDE) engineer did state that some ponding depth must always be present since the weight of the ponded water serves to drive infiltration down through the sand layer.[38] However, the engineer could not provide a minimum depth and stated this varies from one individually designed BMP to another. For the purposes of this survey we noted Maintenance Needed if the ponding depth was one- to three-inches.; or

4. Occasionally we would find that the Forebay was full of wetland vegetation but the filter bed was free of these aquatic plants. Though there's a good chance the water table lies a few inches below the filter bed of these facilities, we rated them Maintenance Needed rather than Failing.

Failing: This rating was assigned if a Sand Filter had any of the following conditions:

1. Water was present on the surface of the filter bed when 48 hours or more had elapsed since runoff from the last storm would have ceased entering the facility;

2. Wetland vegetation was present within the filter bed. To support wetland vegetation the upper 6- to 18-inches of the filter bed must be saturated for at least two weeks during the growing season. The presence of wetland vegetation would therefore indicate that the filter bed was not draining completely within 48-hours. Cattails *(Typha sp.)* were the most common wetland vegetation encountered followed by an occasional appearance of Phragmites *(Phragmites australis)*; or

[38] Personal communication with Stewart Comstock, Maryland Sediment & Stormwater Program.

3. As stated above, there must be at least some ponding area above the filter bed to drive runoff down through the sand filter. If the depth was zero then the BMP was rated as Failing.

Grass Channel, Dry or Bio Swales

The listings provided by the six jurisdictions frequently gave the BMP type as just "Swale" and not the more precise terms Grass Channel, Dry Swale or Bio Swale. When assessing BMPs listed as "Swales" we assumed it was a Grass Channel if it lacked observation wells or the landscaping and concrete outlet typical of a Dry or Bio Swale. Some Grass Channels had check dams. Long, narrow facilities with observation wells, landscaping and/or an outlet were assumed to be a Dry or Bio Swale.

Maintenance Needed: This rating was assigned if a Swale exhibited any of the following conditions:

1. The Swale was so overgrown with weeds that one had difficulty finding the outlet, determining if sediment was present, locating observation wells or check dams.

2. The Maryland Stormwater Design Manual calls for mowing Swales so grass is no higher than four inches. If grass exceeds four inches then Maintenance is Needed.

3. Swales may include Check Dams constructed of stone and occasionally wood placed perpendicular to the flow at one or more points. If sediment has accumulated to half or more of the check dam depth then it should be removed.

Failing: This rating was assigned if a Swale had any of the following conditions:

1. Water was present on the surface of the swale when 48 hours or more had elapsed since runoff from the last storm would have ceased entering the facility;

2. Wetland vegetation was present within the swale; or

3. The swale lacked a ponding area above the filter bed to drive runoff down through the swale. If the depth was zero then the swale was rated as Failing.

Wet Pond

As the name implies, this is a pond that holds a permanent pool of water. Wet Ponds almost always have earth embankments in the Greater Baltimore area. Forebays are a common pretreatment measure. The assessment criteria for a Wet Pond is pretty simple.

Maintenance Needed: This rating was assigned if a Wet Pond had lost 10% or more of the original surface area but less than 50%. The loss was usually due to sediment intrusion then colonization of the sediment with wetland vegetation. The lesser earth embankment issues would also trigger this rating.

Failing: This rating was assigned if a Wet Pond had lost 50% or more of the original surface area.

XI. FINDINGS

Of the 600 BMPs to be surveyed, 30 were dropped because aerial photos indicated they did not exist or would not be visible from public areas. The coordinates of the remaining 570 BMPs were visited as part of the 2015 Greater Baltimore Stormwater Survey. A BMP was found at 59% of the locations visited. As stated earlier, the goal was to assess a minimum of 335 BMPs. This goal was exceeded by assessing 339 BMPs in the Greater Baltimore region.

Percent of BMPs Found

Table 3, below, shows Wet Ponds were located at the highest frequency (81%) with Infiltration Trenches being the least likely to be found (32%). No evidence could be found that a BMP existed at 17% of the coordinates. This could mean the:

- Coordinates were wrong;
- BMP had not been installed; or
- BMP had been removed.

Table 3: Results of Attempt To Locate BMPs

BMP Type	Found	Not Found	Not Visible	Beneath Parking Lot
Bioretention, Micro-Bioretention & Rain Garden	62%	16%	23%	0%
Infiltration Basin	73%	17%	11%	0%
Infiltration Trench	32%	32%	28%	8%
Sand Filter	46%	21%	12%	20%
Swale	55%	17%	28%	0%
Wet Pond	81%	5%	14%	0%

Another 19% were noted as "Not Assessable From Public Areas" which meant that the BMP may be present but could not be seen from the nearest road or other public access point. Rain Gardens on private lots were particularly difficult to find. Rain Gardens, like all BMPs, are located downhill of a house and other impervious surfaces while roads - the primary public access for most BMPs - are frequently uphill of the house. So, in most cases the Rain Garden was blocked by a house.

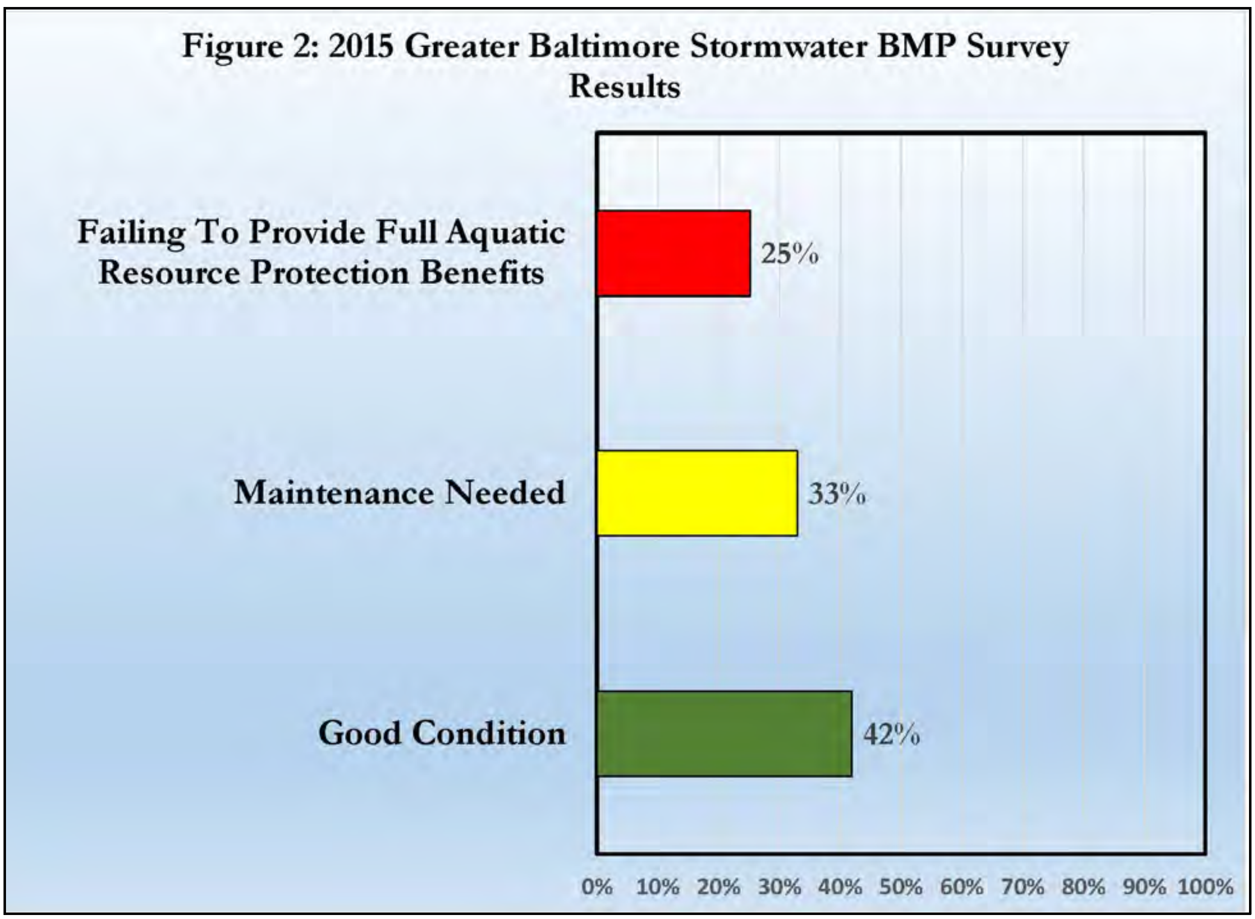
About 5% of BMPs were located beneath a parking lot. Usually the BMP was a Sand Filter or Infiltration Trench. In Baltimore City, most Sand Filters are underground and usually beneath a parking lot. The presence of these BMPs was indicated by grates, manhole covers and access plates. In suburban and rural areas Sand Filters were always in-ground and clearly visible. Two bioretention facilities were found that were not on the City's MS4 list. They were assigned IDs of BCGBS1b (at

Western High School) and BCGBS2b (Mondawmin Mall). Both were included since the City's list had very few bioretention facilities.

Of the 336 BMPs found, 92% were of the same type as identified in the listings obtained from each of the six jurisdictions.

Aquatic Resource Protection Condition

As shown in Figure 2, below, of the 336 BMPs found and assessed, 42% were free of any defects which would have lowered the pollutant removal or groundwater recharge effectiveness. Another 33% had maintenance issues which may have lowered aquatic resource protection benefits or may cause the BMP to fail if left unchecked. And 25% of the BMPs were found to have failed to the point that the facility was no longer providing any benefits. The Center for Watershed Protection study which served as the model for this Survey found a very similar (28%) failure rate among the BMPs assessed in the James River basin.



Indicators of BMP Failure

Table 4, on the next page, shows the indicators of failure for the six BMP categories. All but the Wet Pond depend upon infiltration to remove pollutants and to achieve groundwater recharge.

Table 4: Causes of BMP Failure

Failure Cause	Bioretention Micro-Bioretention Rain Garden	Infiltration Basin	Infiltration Trench	Sand Filter	Grass Channel & Dry or Bio Swales	Wet Pond
BMP does not receive any runoff from impervious surfaces	2%	0%	7%	0%	0%	0%
It takes more than 48-72 hrs after runoff ends for water to drain from the facility, indicating clogging or other infiltration failure.	4%	33%	9%	8%	9%	NA
Runoff storage area lacks the minimum 3-inch ponding depth needed to drive runoff down into the filter layers	5%	8%	NA	NA	10%	NA
Wetland vegetation present which shows BMP is clogged; no longer infiltrates	6%	33%	0%	16%	8%	NA
Vegetation growing from trench indicating storage in stone interstices filled with sediment, which means little room left to store runoff until it can infiltrate.	NA	4%	13%	NA	NA	NA
Trench stone interstices visibly full of sediment, which means little room left to store runoff until it can infiltrate.	NA	4%	13%	NA	NA	NA
Wet pond surface area <50% of original indicating pond well past cleaning point and loss of storage means reduced pollutant removal	NA	NA	NA	NA	NA	47%
Low-Spot on earth embankment which could lead to dam failure during major flood	NA	0%	NA	NA	NA	7%
Wet spot on earth embankment downstream face which could indicate piping & possible dam failure	NA	0%	NA	NA	NA	0%
Wetland vegetation on earth embankment downstream face which could also indicate piping & possible dam failure	NA	0%	NA	NA	NA	0%

While some of the filtering BMPs[39] are designed with an underdrain system which precludes recharge, pollutant removal is still dependent upon infiltration through the filter bed. Infiltration failure was the most common issue precluding aquatic resource protection for five BMP categories. Infiltration Basins exhibited the highest failure rate followed by Sand Filters. The lowest failure rate was observed in the Bioretention, Micro-Bioretention and Rain Garden category.

Drainage Area Issues: Problems were found at a small number of BMPs where impervious surface runoff was partially or completely prevented from flowing into the facility. At one BMP the inlet was higher than the runoff flowing from a parking lot. At another the inlet was blocked. This issue affected 2% of the Bioretention-type facilities and 7% of Infiltration Trenches.

Slow BMP Drainage: The Maryland Stormwater Design Manual requires that most infiltration measures drain within 48 hours of the end of a runoff event, though a few have up to 72 hours. The Manual refers to the facility draining completely from surface of filter bed to the bottom of the BMP. In other words, one would find no water in the observation well 48 hours after runoff ended. Since we did not wish to trespass or to open observation wells, we were limited to looking for runoff ponded on the BMP surface after 48 hours. While June, 2015 was the wettest June on record[40] most of the survey period was dry. Nevertheless, we found that 4% to 33% of the infiltration BMPs assessed held runoff when more than 48 hours had passed. Of the five categories of infiltrating BMPs, Basins exhibited the highest failure rate at 33%. Carroll and Harford counties appear to be the most successful in keeping Infiltration Basins working. Respectively, 55% and 71% of Carroll and Harford Basins were in Good condition.

Wetland Vegetation Present: For wetland vegetation to be present soil must be saturated with water within six- to eighteen-inches of the soil surface for at least two-weeks during the growing season. The Maryland Stormwater Design Manual requires that infiltrating BMPs be installed at least two- to four-feet above the highest expected elevation of the water table. Therefore, if one sees wetland vegetation in an infiltrating BMP then the facility is saturated for some portion of the year. This means the facility is failing for at least part of the year since it no longer infiltrates runoff at those times. Of the five categories of infiltrating BMPs, 0% to 33% supported wetland vegetation. The vegetation was mostly cattails *(Typha sp.)* but occasionally *Phragmites sp.* Again, Infiltration Basins were the BMPs that exhibited the 33% failure rate.

Sediment Accumulations & Other Vegetation Growing From An Infiltration Trench: Infiltration Trenches can be stand-alone BMPs or they may be present in the floor of an Infiltration Basin. Over time sediment can accumulate in the air spaces (interstices) between the stone composing the trench. When new these air spaces account for about 40% of the total volume of a trench. It is in these air spaces that runoff is stored until it can soak into adjacent or underlying soils. As sediment accumulates within the interstices, storage volume decreases. A trench which had sufficient volume to store 90% of all runoff when new may have half that volume 20-years later.

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[39] For the purposes of this report, filtering BMPs include bioretention, micro-bioretention, rain gardens, sand filters and dry or bio swales.

[40] See: https://www.washingtonpost.com/news/capital-weather-gang/wp/2015/06/26/baltimore-locks-up-wettest-june-on-record-d-c-climbing-into-top-5/

As sediment accumulates plants may begin growing from the trench. This plant growth is a strong indicator the trench is failing or at least requires cleaning. Of the Infiltration Basin trenches 4% exhibited this failure indicator. And 13% of Infiltration Trenches were sprouting vegetation. These same percentages of Basin trenches and stand-alone trenches had visible sediment accumulations.

Minimum Ponding Depth: Most infiltrating BMPs are designed to store runoff to a depth of six- to twelve inches above the filter bed or floor. The weight of this depth of water helps to drive runoff down into a filter bed or floor. As depth decreases so may infiltration. It is for this reason that storage depth should not drop to zero, as was found at 5% to 10% of the infiltrating BMPs assessed.

Wet Pond Surface Area: Figure 3 shows that as pond volume declines, so does pollutant removal. Almost half (47%) the Wet Ponds had lost 50% or more of the original surface area. Wet Ponds should be cleaned when more than 10% of the original surface area is lost. Pollutant removal efficiency within a Wet Pond is directly related to volume. As sediment and wetland vegetation accumulates in a pond volume declines and so does aquatic resource protection benefits. There's a common misperception that wetland vegetation enhances pollutant removal. While it is true that vegetation takes up some pollutants during the growing season, much of these pollutants are released in the fall when vegetation dies back and decays.[41] Pollutants that settle to the bottom of a Wet Pond tend to stay there until all the sediments are removed every 20 years or so.

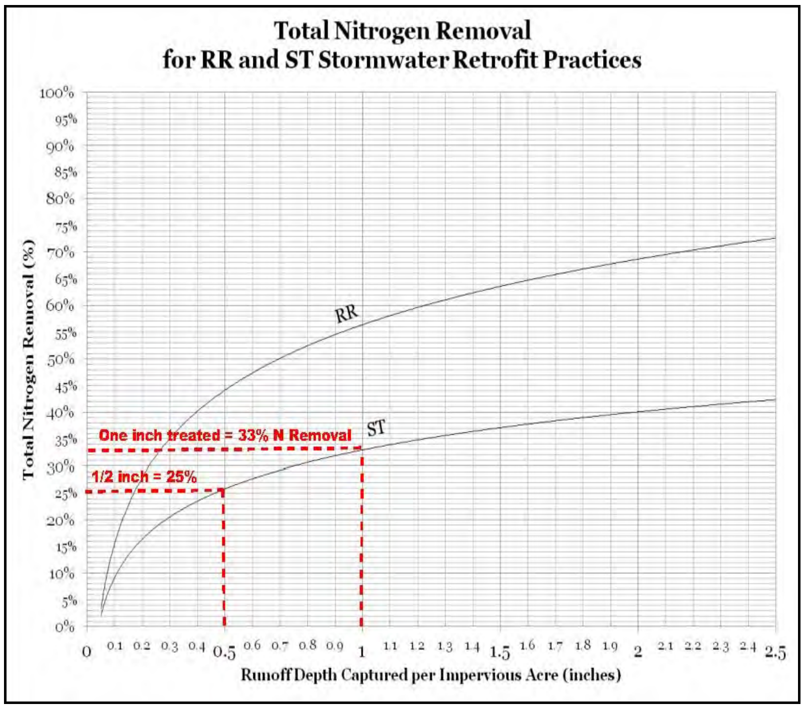


Figure 3: ST curve applies to Wet Ponds. As runoff depth treated increases so does the percent of Total Nitrogen trapped in the pond. New ponds would treat 1 inch of runoff and trap 33% of nitrogen but when 50% of volume lost only 0.5 inches treated and only 25% of nitrogen trapped.

Earth Embankment Issues: Both Infiltration Basins and Wet Ponds may have a substantial earth embankment. An attempt was made to examine each embankment for problem indicators. The

[41] See *Stormwater Runoff Characteristics from a Newly Constructed Subdivision in the Corsica River Watershed*, by Dr. Kenneth Staver, Associate Research Scientist, University of Maryland, College of Agriculture and Natural Resources, Wye Research and Education Center, P. O. Box 169, Queenstown, MD 21658

attempt was only successful half the time due to access problems. Only one problem indicator was found and that was a low-spot on an earth embankment. This low-spot could be a point where flood waters spill over the dam, eroding an ever increasing gully into the earth embankment and causing eventual dam failure. A low-spot was found at two dams. The first was on a very low dam likely posing minimal hazard (AA000640p). The second low-spot was where a pond embankment had washed out a number of years ago (HA0450p).

BMP Age & Failure Rates: The database for five of the six jurisdictions included the date a BMP was approved, built and last inspected. However, the data was provided for some but not all BMPs. Approval and Built Dates were the most common present. The average age (Built Date) of the BMPs assessed through this study was 14 years. Only one category of BMPs had a sufficient amount of data to make a comparison between average age and condition: Bioretention, Micro-Bioretention and Rain Gardens:

- Good = 4.9 years average age;
- Maintenance Needed = 6.6 years average age; and
- Failing = 10.0 years average age.

BMPs in this category rated Good were last inspected one- to six-years ago with an average of 3.0 years since the last inspection.

BMP Maintenance Issues

Table 5, on the next page, lists maintenance issues noted for each of the six BMP categories. While none of these issues would eliminate the aquatic resource benefits provided by any of the BMPs, they could cause a partial diminution. At the very least the issues would increase the likelihood that a facility may fail.

Bioretention, Micro-Bioretention & Rain Gardens: For this category of BMPs the most common maintenance issue was the presence of sediment on the filter bed surface. Over time continued sediment accumulations would reduce storage volume. Instead of having the capacity to treat the first inch of runoff only the first half-inch might be treated. Put another way, managing the first inch treats 90% of all runoff while a half-inch only treats 60%. Sediment accumulations also increase the likelihood of clogging at the filter surface, which would eliminate the passage of runoff down through the filter bed. For 11% of these BMPs a portion of the sediment was coming from areas of exposed soil within the drainage areas. Erosion on exposed BMP side slopes was another source of sediment at 18% of these BMPs. At the fifth of the BMPs which have forebays, sediment had accumulated to the 50% cleanout level.

More than a third of these BMPs had gravel diaphragms to prevent sediment entry but at a fifth the interstices of the stone was filled with sediment, requiring cleaning. And so much sediment had accumulated in some diaphragms that plants were growing from the stone.

With regard to filter bed cover, only 9% had two- or three-inches of wood mulch. Another 25% had a lesser depth of mulch which triggers the need for maintenance. Mown grass was found at a fourth of these BMPs. Though wood mulch was originally required, mown grass is becoming

Table 5: BMP Maintenance Issues

MAINTENANCE ISSUE	Bioretention Micro-Bioretention Rain Garden	Infiltration Basin	Infiltration Trench	Sand Filter	Grass Channel & Dry or Bio Swales	Wet Pond
Active soil erosion within BMP drainage area which reduces storage capacity and may cause clogging	11%	4%	13%	6%	19%	6%
Forebay present	**11%**	**17%**	**6%**	**38%**	**12%**	**26%**
Sediment occupies more than 50% of forebay which triggers need to clean	2%	9%	0%	9%	4%	6%
Grass filter strip present	**26%**	**20%**	**38%**	**32%**	**40%**	**0%**
More than 25% of strip filled with sediment which triggers need to clean	0%	0%	0%	2%	0%	0%
Gravel diaphragm present	**39%**	**4%**	**0%**	**4%**	**8%**	**0%**
Stone interstices filled with sediment and triggers need to clean	21%	0%	0%	4%	4%	0%
Vegetation growing from interstices indicating excessive sediment accummulation, loss of storage and need to clean	10%	0%	0%	0%	4%	0%
Excessive sediment entering main portion of BMP where pollutant removal occurs	38%	22%	25%	6%	37%	23%
Sediment visible in stone interstices which may indicate cleaning is needed	**NA**	**NA**	6%	**NA**	**NA**	**NA**
BMP floor cover:						
2" to 3" of mulch present as required; not a maintenance issue	9%	NA	NA	NA	NA	NA
Mulch present, but less than two inches, which requires maintenance	25%	NA	NA	NA	NA	NA
Mown grass as required	25%	50%	NA	74%	64%	NA
Taller grass which may indicate mowing needed	NA	0%	NA	NA	8%	NA
Other landscaping which is likely per design; not a maintenance issue	31%	NA	NA	NA	12%	NA
Excessive weed growth indicating the need for maintenance	23%	41%	NA	23%	4%	NA
Soil exposed on the BMP treatment area floor which triggers the need for maintenance	30%	0%	NA	0%	20%	NA
Other maintenance issues	0%	2%	0%	0%	0%	0%

Table 5: BMP Maintenance Issues *continued*

MAINTENANCE ISSUE	Bioretention Micro-Bioretention Rain Garden	Infiltration Basin	Infiltration Trench	Sand Filter	Grass Channel & Dry or Bio Swales	Wet Pond
Ponding depth only 1" - 3" inches which may be insufficient to drive runoff down into filter bed	11%	2%	0%	0%	19%	NA
Observation well cap missing which may invite objects being placed in well	1%	2%	6%	0%	7%	NA
Sand filter bed covered with excessive sediment which may lead to clogging	NA	NA	NA	6%	NA	NA
BMP slopes eroding releasing sediment that may clog BMP bed or diminish storage	18%	NA	NA	11%	26%	0%
Earth embankment issues:						
Embankment not visible through vegetation making assessment difficult	0%	9%	NA	0%	0%	9%
Animal burrows present which may jeopardize dam stability	0%	7%	NA	0%	NA	0%
Trees, shrubs present on embankment which may jeopardize dam stability	0%	11%	NA	0%	0%	19%
Erosion occuring on embankment which may jeopardize dam stability	0%	2%	NA	0%	0%	6%
Excessive sediment accumulation above check dams which eliminates storage and lowers pollutant removal as well as recharge	NA	NA	NA	NA	41%	NA
Other maintenance issues	1%	0%	0%	2%	7%	0%

increasingly accepted and common in Bioretention, Micro-Bioretention and Rain Garden facilities. While another third lacked mulch the facilities were attractively landscaped which, like those with grass, may be providing benefits comparable to those with wood mulch. Excessive weed growth at 23% of the BMPs made it very difficult to find outlets, observation wells, or to even tell what sort of filter bed cover was present. Finally, exposed soil was present on 30% of the filter beds necessitating either a reapplication of mulch, grass reestablishment or enhanced landscaping.

At 11% of these BMPs the depth from the filter bed surface to the first point where runoff could exit was only one- to three-inches. When new these BMPs have a storage (ponding) depth of six- to twelve-inches. The weight of this depth of runoff is more than sufficient to force it down into the filter bed. But a depth of only one- to three-inches may not be sufficient to cause this downward infiltration. These 11% of BMPs need to be restored to the original design depth.

Infiltration Basins: Excessive sediment entry was a maintenance issue at 22% of the Infiltration Basins assessed. Of the 17% of Basins with Forebays, half had lost 50% or more of the original volume triggering the need to clean these Forebays. Almost half (41%) of the Basins were overgrown with weeds making it difficult to locate observation wells and to assess outlet condition. Basins were originally designed to hold a foot or more of runoff while it infiltrated through the Basin floor. A small number of Basins (2%) had a storage depth of only one- to three-inches and required cleaning.

Trees or shrubs were found growing on 11% of Basin earth embankments. Should these trees mature, then topple a large amount of soil could be removed from the embankment along with the root system. The loss of so much soil could lead to dam failure during major floods. Animal burrows were present on 7% of embankments and erosion was occurring on 2%, both conditions further lower dam stability. While 41% of Basin floors were overgrown with weeds, most (91%) embankments are regularly mowed.

Infiltration Trench: Active soil erosion was present in the area draining to 13% of the Infiltration Trenches assessed. This partly accounted for the 25% of trenches with excessive sediment accumulations requiring cleaning. Caps were missing at 6% of the Trenches with Observation Wells. The missing cap could invite passers by to drop objects into the well which could eventually eliminate the ability to detect water levels within the well.

Sand Filter: The Pretreatment Sediment Chambers present at 38% of Sand Filters appeared to be very effective at keeping sediment from entering the filter bed. Only 6% of Filter Beds exhibited excessive sediment entry. However, 9% of the Chambers do require sediment removal as do 2% of Grass Filter Strips and 4% of Gravel Diaphragms. Erosion within the filter area was observed at 11% of the Sand Filters. Filter beds are supposed to be covered with mown grass and 74% were. Another 23% suffered from excessive weed growth making assessment difficult.

Grass Channels, Dry & Bio Swales: Excessive sediment entry was a problem at 37% of the Channels-Swales assessed. At Channels or Swales with check dams, 41% were full of sediment and need to be cleaned. At 19% there were areas of exposed soil in the drainage area contributing sediment. At 26% the side slopes or floor of the Channel-Swale was eroding. Grass Filter Strips were present at 40% of these BMPs but none of the Strips had accumulated sediment to the 25% clean-out level. However, 4% of the Gravel Diaphragms did require cleaning. Nearly three-fourths (76%) of the Channels-Swales had the required cover of regularly mown grass or other well-tended landscaping. However, exposed soil was visible on the floor of 20% of the Channels-Swales. A ponding depth of only one- to three-inches was found at 19% of these BMPs. The design for each should be checked to see if the original ponding depth needs to be restored.

Wet Pond: This survey noted that 23% of the Wet Ponds assessed had an excessive accumulation of sediment. Only 26% of the Ponds benefitted from a Forebay and 6% of the Forebays had reached the 50% sediment accumulation point where cleaning is triggered. Trees or shrubs were present on 19% of the Pond earth embankments. Erosion was occurring on 6% of the embankments. Lack of regular mowing had lead to vegetation growth so excessive that 9% of the embankments could not be assessed.

BMP Appearance Issues
Three questions were included on the checklists which have little to do directly with aquatic resource protection but mean everything with regard to public acceptance when it comes to having BMPs near homes, places of business, institutions, etc:

- Is the facility free of dead, dying or invasive vegetation?
- Is the facility free of trash or other debris?
- With regard to visual appearance, would you want this BMP next to your home?

Table 6: BMP Appearance

APPEARANCE FACTOR	Bioretention Micro-Bioretention Rain Garden	Infiltration Basin	Infiltration Trench	Sand Filter	Grass Channel & Dry or Bio Swales	Wet Pond
Free of dead, dying vegetation	93%	98%	100%	95%	92%	95%
Free of trash	82%	100%	100%	98%	88%	100%
Would you want this BMP next to your home?	67%	67%	75%	83%	74%	73%

Table 6, shows that Survey volunteers would not want a third of the Bioretention category BMPs and a third of the Infiltration Basins near their homes. The undesirable bioretention facilities mostly had an abundance of trash while the problem Basins were no longer being mowed. These overgrown Basins were mostly failing too as indicated by standing water or wetland vegetation.

Assessment Accuracy
Howard County stormwater officials visited a number of the BMPs assessed by Greater Baltimore Survey volunteers. Of the 118 BMPs assessed, Howard officials found that:

- Two BMPs were listed by CEDS as Failing but are actually in Good condition;
- Two others were listed as Failing but were changed to Maintenance Needed;
- Two BMPs were listed as Wet Ponds but are now Extended-Detention facilities, which will be deleted from the survey; and
- One BMP was incorrectly assessed since it was mistaken for another nearby BMP.

In summary, of the 118 BMPs, the rating of only four (3%) was incorrect based on the GBS criteria. However, GBS volunteers could only assess BMPs from adjoining public areas. County officials do not have this limitation. When Howard County officials ventured into the BMPs for a closer inspection they found problems which were not visible from public areas. This is not surprising. In fact, it's something we've always anticipated. But the 97% accuracy rate is reassuring that the GBS procedure does produce credible findings.

Findings By Jurisdiction

Table 7, on the next page, shows the total number of BMPs randomly selected for the assessment pool for each category and jurisdiction. Also shown in Table 7, is the number actually selected for assessment along with the number assessed and the percent assessed. Baltimore City had the highest percent of BMPs assessed (77%) and Anne Arundel was the lowest (48%). An abundance of hard to find Rain Gardens accounted for the lower percentage for Anne Arundel County. Of the six BMP categories, Infiltration Trenches were the most difficult to locate or assess (27%), while Wet Ponds (81%) followed closely by Infiltration Basins (76%) were the easiest.

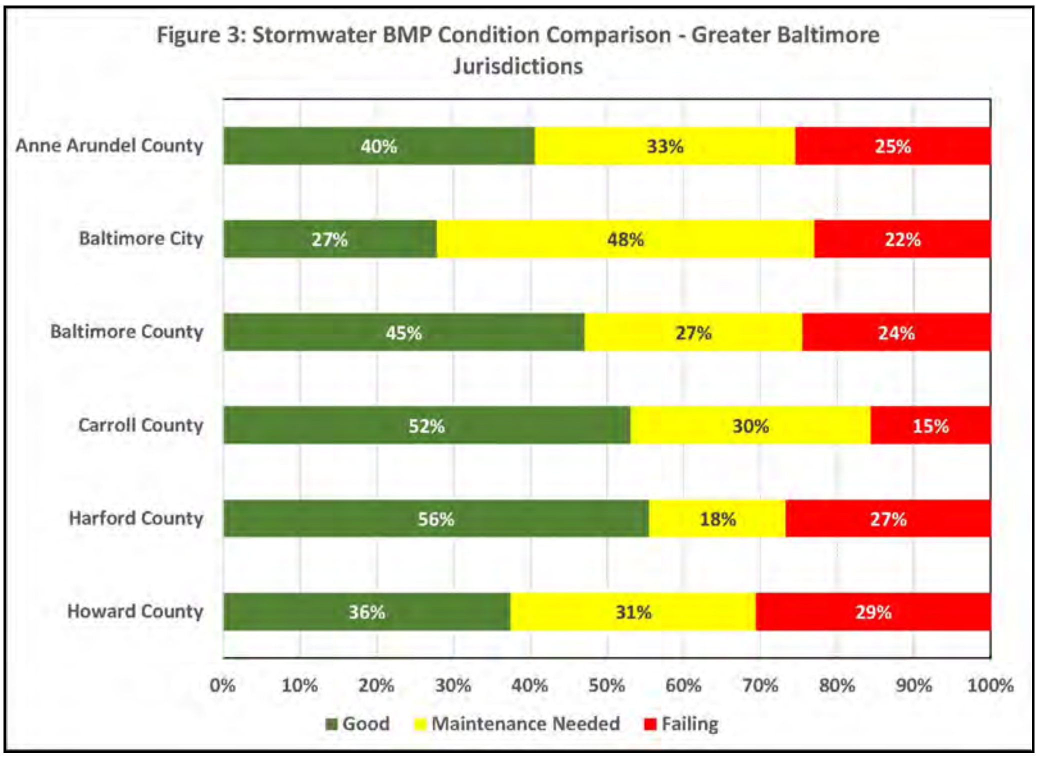


Figure 3 provides a comparison of BMP ratings for the six jurisdictions. If one had to select a single jurisdiction that seems to be the leader in BMP maintenance, it would be Carroll County. For the other five localities it's a bit of apples and oranges. On the one hand Baltimore City had the second lowest BMP failure rate as well as the lowest percent of BMPs in Good condition. Carroll County along with Harford appear particularly successful in keeping Infiltration Basins and Infiltration Trenches in Good working order. Howard County had an unusually large percentage of Wet Ponds that had lost more than 50% of the original surface areas and six no longer held a permanent pool of water. But most of these ponds may have been built during the early days of Columbia which would make them among the oldest in the region.

Baltimore City had an abundance of Underground and Perimeter Sand Filters. Seventeen of these BMPs were visited and none could be assessed. Making an assessment would have required lifting a heavy manhole cover or steel access plates. We didn't do this for two reasons. First, its dangerous. Second, it would have required the owners permission. We understand that similar BMPs were once

Table 7: Greater Baltimore Region Stormwater BMPs To Be Assessed & Actually Assessed

	NUMBER OF BMPs BY TYPE						
BMP Category	Anne Arundel	Baltimore City	Baltimore County	Carroll	Harford	Howard	Total
Bioretention, Micro-Bioretention & Rain Gardens							
Total Number in BMP Category	62	47	42	5	10	63	229
Number To Be Assessed	61	40	42	5	10	63	221
Number *ACTUALLY* Assessed	22	36	26	4	10	31	129
Percent Actually Assessed	36%	90%	62%	80%	100%	49%	58%
Infiltration Trench							
Total Number in BMP Category	13	1	13	13	13	12	64
Number To Be Assessed	13	1	13	13	13	12	65
Number *ACTUALLY* Assessed	0	0	2	6	4	5	17
Percent Actually Assessed	0%	0%	15%	46%	31%	42%	26%
Sand Filter							
Total Number in BMP Category	12	58	12	12	12	13	119
Number To Be Assessed	12	13	12	12	12	13	74
Number *ACTUALLY* Assessed	5	8	5	10	9	10	47
Percent Actually Assessed	42%	62%	42%	83%	75%	77%	64%
Wet Pond							
Total Number in BMP Category	14	19	14	0	15	15	77
Number To Be Assessed	14	15	14	0	15	15	73
Number *ACTUALLY* Assessed	14	14	8	0	12	11	59
Percent Actually Assessed	100%	93%	57%	0%	80%	73%	81%
Infiltration Basin							
Total Number in BMP Category	15	2	13	13	13	13	69
Number To Be Assessed	15	2	11	13	13	13	67
Number *ACTUALLY* Assessed	14	0	10	11	7	8	50
Percent Actually Assessed	93%	0%	91%	0%	54%	62%	75%
Swale							
Total Number in BMP Category	17	9	15	2	8	16	67
Number To Be Assessed	10	9	14	2	8	16	59
Number *ACTUALLY* Assessed	5	5	4	2	3	10	29
Percent Actually Assessed	50%	56%	29%	100%	38%	63%	49%
Total Number in BMP Category	**133**	**136**	**109**	**45**	**71**	**132**	**626**
Number To Be Assessed	**125**	**80**	**106**	**45**	**71**	**132**	**559**
Number *ACTUALLY* Assessed	**60**	**63**	**55**	**33**	**45**	**75**	**331**
***Percent* Actually Assessed**	**48%**	**79%**	**52%**	**73%**	**63%**	**57%**	**59%**

used in Washington, D.C. but no longer due to inspection problems. However, Baltimore City officials reported that they had no difficulty assessing underground sand filters. Nevertheless, underground sand filters will not be included in future surveys.

How Stormwater Maintenance Is Handled By Each Jurisdiction
The following information was obtained from the most recent Municipal Separate Storm Sewer System (MS4) annual report for each jurisdiction. The 2014 report was found online for five of the six jurisdictions. Only the 2013 Harford County report was found online. The reports vary considerably in the type and detail of information provided with regard to each jurisdictions stormwater BMP maintenance efforts.

Anne Arundel County
With regard to existing stormwater BMP inspection priorities, the 2014 Anne Arundel County MS4 Annual Report states on page IV-20:

1. On a weekly basis, schedule triennial maintenance inspections by using the SWM Urban BMP Database. Review the proposed weekly inspection schedule with the assigned supervisor and adjust accordingly. A priority is to be placed on the following BMPs:

   - Large BMPs serving commercial and industrial projects;
   - Large BMPs serving single-family subdivisions with private stormwater management; and
   - Large BMPs serving multi-family subdivisions.

2. Triennial maintenance inspections for private BMPs serving single-family residential lots or public devices not maintained by DPW shall be given a secondary scheduling priority. These should only be inspected if an inspection request is received by the responsible agency or a complaint is received.

With regard to enforcement procedures, the following appears on page IV-19:

> The Anne Arundel County Department of Inspections & Permits coordinates with the County Office of Law on the enforcement of violations where the field-generated Maintenance Correction Notices have been ignored. A formal Violation Notice Letter was developed by the Office of Law to be sent by certified mail to the appropriate property owners when a Maintenance Correction Notice goes unheeded. If the Violation Notice Letter does not result in compliance action, the Office of Law will take the appropriate legal actions to enforce violations and obtain compliance.

Baltimore City
The portions of the 2014 Baltimore City report pertaining to stormwater BMPs only appears to address measures required for new development. The report does not appear to contain any information on inspection and maintenance of existing BMPs.

Baltimore County
The 2014 Baltimore County MS4 report contains an extensive analysis of the pollutant loads captured by the existing 3,119 stormwater BMPs. The captured phosphorus load is 18,211 pounds which is 50% of the total load passing through the BMPs. For nitrogen, 300,174 pounds or 22% of the total load delivered to existing BMPs was kept out of nearby waters. An impressive 16,155,883 pounds of solids were captured which was half the sediment that passed through the existing BMPs.

For all three pollutants, Extended-Detention (ED) Ponds accounted for about a third to half the load captured. Roughly half of the 3,114 existing BMPs are Extended Detention (ED) Ponds. Extended Detention Ponds were not included in the 2015 Greater Baltimore Survey due to the relative ineffectiveness of individual facilities with regard to pollutant removal and lack of recharge. Given the sheer number of these facilities and the large reduction in pollutant loads, consideration should be given to including Extended Detention Ponds in future Surveys.

Carroll County

The 2014 Carroll County MS4 report contains the following with regard to public and private BMP maintenance:

> Residential stormwater management facilities and storm sewer systems in unincorporated areas are owned by the County. Commercial and industrial facilities are maintained by the property owners.

The following excerpt addresses enforcement:

> Inspections of these facilities are handled by the EISD[42]. Each facility is inspected every three years, with letters sent to the owner indicating the condition of the facility and the amount of time allowed for compliance to be achieved, if necessary. In the case of County-owned structures, the notice is sent to the Bureau of Facilities. The EISD performed 290 inspections this year, resulting in 98 corrective actions. Follow-up inspections are performed to ensure compliance has been achieved in a timely matter. As of June 30, 2014, 70 of those facilities have been brought into compliance. In cases where violations still exist, Notices of Violations are sent, allowing an additional amount of time to resolve issues. During the period of July 1, 2013, to June 30, 2014, 10 Notices of Violations were issued. The remaining 18 have been notified, and EISD is awaiting corrective action.

Harford County

The 2013 Harford County MS4 report noted that 347 stormwater BMP inspections were conducted and 155 of the facilities (45%) were found to be in compliance. The following excerpt elaborates:

> During calendar year 2013, a total of three hundred forty seven (347) stormwater management facilities were inspected for preventative maintenance. A total of one hundred fifty five (155) facilities were in compliance with Harford County's stormwater management regulations (Appendix K).
>
> Two hundred fifty six (256) sites were new for 2013. Ninety eight (98) of these facilities were in compliance with Harford County's stormwater management regulations.
>
> Two hundred thirty three (233) sites were not in compliance at the end of 2012. Ninety one (91) of these sites were reinspected in 2013; fifty seven (57) are now in compliance. One

42 Environmental Inspections Services Division

hundred forty three (143) sites that were not in compliance at the end of 2012 were not reinspected in 2013. These sites will be reinspected in 2014.

Ratings, which reflect the condition of the stormwater facility, were provided for each inspection. One hundred ninety seven (197) or fifty four percent (54%) of the overall inspections were rated a 1 or 2 which equates to minimal maintenance such as mowing and/or clearing debris from the barrel or storm drain outfalls.

Fifty four (54) or fifteen percent (15%) of the overall inspections were rated with a 3 requiring a moderate amount of work such as brush or tree removal from the dam.

Four (4) sites had a rating of 4 which included major problems with the principal spillways.

On average, two (2) inspections along with notices were sent to the owner before compliance was achieved. Correction action will be pursued on the remaining sites in the 2014 calendar year. Four hundred eighty (480) maintenance inspections were conducted.

Howard County
The following excerpt from the Howard County 2014 MS4 report describes the inspection process and a common difficulty:

> The general procedure for the inspection of privately maintained facilities is to use the owner information in the BMP database developed by the County to give prior notification to the BMP owners of the County's intent to inspect their facility; perform the inspection; provide the owner a complete record of the results of the inspection, including deficiencies that need to be repaired; then follow up with the owner to ensure the necessary repairs are made within a reasonable time frame. The County has developed an extensive component to the BMP database to allow tracking of the inspection and maintenance process in detail for each BMP inspected. The County has found that considerable follow-up is needed for owners that do not readily respond to initial inspection notifications and the results of the inspections with repairs. Further, several site visits may be required of County inspection staff to meet with BMP owners and their maintenance contractors to better explain the repairs needed and to follow up until the repairs are completed.

Inspection & Maintenance Workload, Staffing & Enforcement Actions
Table 8, on the next page, provides data for each of the six jurisdictions with regard to the:

- Number of BMPs that are maintained publicly and privately. The publicly-maintained facilities are kept in working order by the jurisdiction. The private BMPs are maintained by the property owner or some entity other than the local jurisdiction.
- Number of inspectors, supervisors and maintenance staff;
- Number of BMPs per inspector, number of BMPs inspected annually and the number of BMPs one full-time inspector can keep in good condition in one year; and
- Enforcement actions for the most recent year.

Table 8: Local Stormwater BMP Inspection Program Characteristics

	STORMWATER BMP MAINTENANCE RESPONSIBILITY			STORMWATER INSPECTION STAFF (Full-Time Equivalent)				INSPECTION WORKLOAD			MOST RECENT YEAR ENFORCEMENT ACTIONS		
Jurisdiction	Publicly Maintained	Privately Maintained	Number of BMPs	Inspectors	Supervisor	Crew Chief	Field Crew Members	BMPs Per Inspector	Annual Stormwater BMP Maintenance Inspections	Number of BMPs Inspected Annually By One Inspector	BMPs In Compliance	Correction Notices Issued	Notices of Violation Issued
Anne Arundel County	1,100	9,353	10,453	6	1	-	-	1,742	2,560	427	1,593	967	-
Baltimore City	10	385	395	1	1	-	-	172	221	221	172	24	1
Baltimore County	1,297	1,850	3,147	5	1	1	7	629	1,438	288	620	0	0
Carroll County	280	629	909	4	1	1	5	182	578	145	847	62	14
Harford County	141	982	1,123	3	1	-	-	374	480	160	155	258	67
Howard County	1,166	3,248	4,414	6	1	1	10	736	1,770	295	852	918	1
Total	**3,994**	**16,447**	**20,441**	**25**	**6**	**3**	**22**	**3,836**	**7,047**	**1,535**	**4,239**	**2,229**	**83**
Average	**666**	**2,741**	**3,407**	**4**	**1**	**1**	**7**	**639**	**1,175**	**439**	**707**	**372**	**17**

Table 8 indicates that on average 20% of the 20,441 BMPs in the region are publicly maintained. Generally these are BMPs that treat runoff from public roads or other publicly owned property. In some jurisdictions a portion of publicly maintained BMPs serve private residential communities.

Table 8 also indicates that one full-time inspector can evaluate the maintenance needs and do the follow-up work needed to get maintenance completed for about 400 BMPs per year. But as shown in Table 8, the actual values range 50% to 100% above and below these averages.

Of the 7,047 BMPs inspections performed by the six jurisdictions, 32% resulted in the issuance of correction notices. The Greater Baltimore Survey noted that 25% of the BMPs evaluated were Failing. Since Survey volunteers lacked the full access inspectors have, it is understandable that these local officials would find more failures. Nevertheless, the close agreement of these two values - 25% vs. 32% - attests to the accuracy of the evaluations performed by the Greater Baltimore Survey volunteers.

All six jurisdictions reported that most BMP owners comply with correction notices without any further action. In fact, Table 8 shows that Notices of Violation were only necessary to get compliance with a mere 4% of the correction notices.

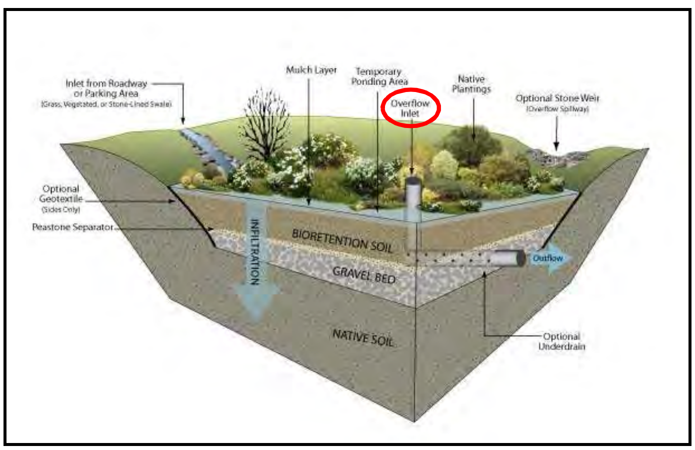
Attachment A: BMP Factsheets

Assessing the Condition of Bioretention, Micro-Bioretention & Rain Gardens

Bioretention, Micro-Bioretention and Rain Gardens share the same basic design and are among our most effective and long-lasting stormwater Best Management Practices (BMPs). Bioretention is also likely to become ***THE*** most common BMP in the Chesapeake Bay watershed. Bioretention and related facilities can remove 80% to 95% of the pollutants entrained in runoff. They also allow runoff to flow into underlying soils providing the groundwater recharge essential to maintaining dry-weather inflow to wetlands, streams and other waterways.

Basic Bioretention Design

As illustrated below, this BMP is constructed by first excavating a pit or trench three- to six-feet deep. Perforated pipe is placed in a gravel bed on the bottom. The pipe connects to a storm drain system or discharges into a channel. A "bridging" material is placed above the gravel then several feet of a sand-organic matter



From Douglas County, Nebraska Environmental Services

mix, which resembles planting soil. The surface is usually covered with two- or three-inches of seasoned, hardwood mulch. The surface is depressed about a foot below the first point where runoff could flow into the spillway to exit the BMP *(see Overflow Inlet above)*. The size of the BMP is adjusted so the first inch of runoff from all impervious surfaces draining to it will be stored in the surface depression until it can soak down through the mulch, sand and gravel layers.

Spillway inlet openings set 12-inches above mulched surface forces runoff to filter down through mulch, sand, then gravel layers before infiltrating underlying soils

Variations On A Basic BMP Design

Three BMPs share the same basic design shown to the left: Bioretention, Micro-Bioretention and Rain Gardens. These BMPs are placed in locations where runoff from a building, street, parking lot or all three can be intercepted then treated. Originally, bioretention facilities were designed to treat runoff from up to ten acres. Micro-Bioretention treats no more than a half-acre and is thought to provide environmental benefits superior to conventional bioretention while possibly lasting much longer. Rain Gardens are mostly used to treat runoff from a home or other, small impervious surface - 2,000 square feet or less.

Sediment Lethal To Bioretention

Sediment deposit in BMP

The entry of eroded soil and other sediment can quickly form an impermeable layer on the surface of bioretention facilities which prevents runoff from filtering down through the mulch, sand and gravel layers then into underlying soils. Older facilities may have been protected with a forebay. But grass filter strips and gravel diaphragms are more common at all three BMP types. The factsheet *Forebays & Other BMP Pretreatment Measures* describes how to assess the condition of these sediment trapping measures. Of course note whether you see any evidence of sediment deposits on the BMP surface.

Runoff Must Drain Completely Within 48 Hours

The tremendous benefits of bioretention only result if runoff infiltrates the surface and filters down through the sand and gravel layer. When a site is composed of clayey or other soils that retard infiltration the underdrain pipe is left open and connected to a discharge point. Otherwise the underdrain is either not installed or left capped. Most facilities will drain within six-hours after runoff ceases to enter. But you should only note a failure if you see standing water in a facility when more than 48 hours has passed since runoff ended. If cattails and other wetland vegetation are present then a bioretention facility has been failing for a long period of time.

Cattails have taken over this bioretention BMP indicating the surface has been clogged for a long time.

Check Spillway For Defects That Prevent Ponding

Runoff must be able to pond to a depth of up to a foot on the BMP surface. Generally facilities are sized so this foot of storage captures 90% of all runoff from the rooftops, streets and other impervious surfaces draining to the BMP. Occasionally you may find that natural or human action prevents ponding. Pictured below are two inlets where someone drilled holes and cut a V-Notch to prevent ponding. Both are illegal.

Hole drilled through inlet wall

V-Notch cut to prevent ponding

Assessment Summary

1. Is there a depth of at least 6-inches from the BMP surface to the first point where runoff could flow from the facility? If no then the facility must be cleaned to restore a minimum 12-inch storage depth.

2. Is exposed soil present in the land area draining to the BMP? If yes then these soils must be stabilized quickly.

3. If a forebay or other protection measures are present then are they preventing sediment from entering the BMP?

4. Do you see any indication that the protection measures require cleaning? See the *Forebays & Other BMP Pretreatment Measures* factsheet for specific points to assess.

5. If the BMP contains slopes then are there signs of erosion; are the slopes well-vegetated/mulched?

6. Is wetland vegetation present within the BMP?

7. Is water present in the BMP when more than 48 hours have passed since runoff ceased?

8. Can you see the surface of the sand-organic matter mix through the mulch? If yes then the mulch layer requires replacement using well aged (6- to 12-month old) shredded or chipped ***hardwood*** mulch.

9. Is dead or dying vegetation present within the facility?

10. Is the BMP heavily overgrown with vegetation? Is it difficult to see the spillway or the BMP surface?

ASSESSING INFILTRATION BASINS

Infiltration basins are among ***THE*** most effective measures for keeping stormwater pollution out of nearby waterways. Basins are constructed on sandy or other, highly permeable soils. The basin should hold water no more than two days after each storm, thus negating mosquito problems. Runoff soaks down through the permeable soils on the basin bottom which achieves an 80% to 95% nutrient and sediment removal rate. Basins also provide groundwater recharge, prevent stream channel erosion and moderate flooding.

Is It An Infiltration Basin

Infiltration basins resemble Dry Ponds and Extended-Detention ponds. To function effectively runoff must pond to a depth of a foot or two above the bottom of the basin. So the first spillway opening allowing runoff to exit will be at least a foot or two above the basin floor.

Note that the lowest opening on both of these spillways (above-right) is at least a foot or two above the basin floor

Dry Pond opening is at spillway bottom

Gravel covers perforated pipe allowing this extended-detention pond to drain completely

Infiltration basin with infiltration trench extending from spillway

Infiltration Trench

In some basins you'll find a gravel structure resembling an infiltration trench which enhances the movement of runoff down through the basin floor. Such a trench is shown in the photo above.

Observation Wells

Many infiltration basins have an observation well or two made of white, four- to six-inch plastic pipe, like that pictured to the right. ***Please do not remove the cap from the well.***

Observation Well

Sediment Entry

Over time sediment and other material can accumulate within the stone trench or on the basin floor, depleting the area needed to store runoff until it can infiltrate underlying soil. The sediment can also seal the floor preventing infiltration which turns the BMP into a far less effective Wet Pond. If you find cattails and other wetland plants growing throughout the Basin then failure has occurred. Most basins will have a pretreatment system such as a forebay. A layer of sand over the Basin floor can also serve as a pretreatment measure. The sand is removed and replaced whenever sediment accumulations become noticeable.

Sediment Forebay

Pond Embankment Settling

Many Infiltration Basins are created by placing a ridge of earth across a shallow valley. If flooding exceeds the capacity of the principal concrete or metal spillway, than waters may flow over the top of the embankment and erode a breach in the dam. Over time portions of an earth embankment may settle more than others. This *differential settlement* can lead to low spots which become potential overflow points. To check for this stand back far enough so you can see the entire embankment. The top should be nice and straight. However, many basins have an intentional low-spot called an emergency spillway. Note any low-spots on your assessment form.

Pond embankment failure from USDA ARS

Straight, Level Earth Embankment; No Low Spots; No Trees or Burrows on Embankment

Groundhogs and other animals can make burrows sufficiently deep within an embankment to potentially contribute to failure. Trees are prohibited on earth embankments for this same reasons.

Groundhog burrow

No trees on dam embankment

Mowing

Infiltration basins are required to have a grass floor. Periodic mowing (quarterly) appears to be associated with Infiltration Basins that continue functioning over a number of years or decades. Infiltration Basins overgrown with other vegetation almost always exhibit signs of failure, such as standing water long after the last storm, wetland vegetation, etc.

Assessing Infiltration Basins

1. If soil is exposed to erosive forces within the area draining to an Infiltration Basin, then the soil must be mulched-seeded as quickly as possible and runoff diverted away from the basin in the meantime.

2. Is a forebay or other pretreatment measure present?
   a. If **yes**, then does the pretreatment measure meet the criteria set forth at the end of the *Forebays & Other BMP Pretreatment Measures* factsheet?
   b. If you see evidence that a layer of sand was once placed over the floor as a way to keep sediment from clogging the floor surface, then has any of the sand been covered with sediment?
   c. If sand is absent then are sediment deposits visible within the Basin; or
   d. Are gullies, exposed soil or other signs of erosion present on the Basin side slopes?

3. An infiltration basin probably needs maintenance if:
   a. Cattails or other wetland vegetation are present;
   b. Water remains in the basin more than 48 hours following a storm, or
   c. The basin overflows into the concrete spillway when less than an inch of rain falls in a 24-hour period.

4. If an Infiltration Trench is present on the Basin floor than check it for all the items presented in the *Infiltration Trench* factsheet.

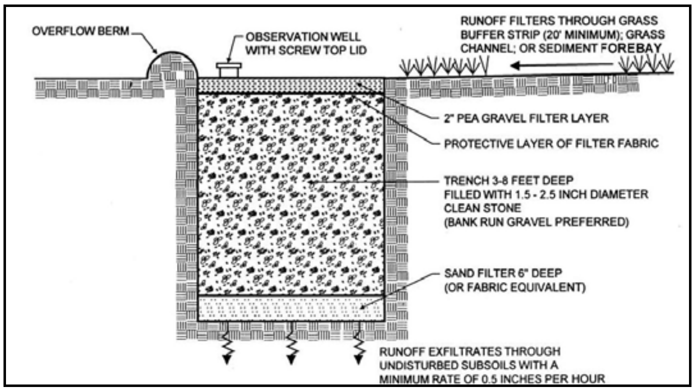
5. If the Basin has an earth embankment then check it for:
   a. Low spots;
   b. Animal burrows; or
   c. Trees growing on the embankment.

6. If an observation well is present then note whether the cap is missing. ***You should never remove the cap from an observation well.***

ASSESSING INFILTRATION TRENCHES

Infiltration Trench With Exposed Stone

Infiltration trenches are among ***THE*** most effective measures for keeping stormwater pollution out of nearby waterways. Unlike the infiltration trench pictured to the right, some are covered with grass and are pretty much invisible.



Infiltration Trench from Maryland Stormwater Design Manual

As illustrated above, a trench is excavated four feet or more into permeable (sandy, low-clay) soils, filled with two-inch stone, covered with a layer of filter cloth, and a thick growth of grass is established on the surface. Many infiltration trenches have an observation well or two made of metal or plastic pipe, like those pictured below.

Metal observation well

Plastic PVC Observation Well

The amount of pollution washed by rain from a residential or commercial area can be two- to twenty-times greater than that from a forest. Runoff from rooftops, streets, parking lots and other impervious surfaces enters the trench by either flowing into the surface by way of a buried storm drain pipe. The air spaces within the stone reservoir store runoff until it can soak (infiltrate) into the adjoining soils.

As runoff percolates through the soil, 80% to 95% of the pollutants washed from streets and other impervious surfaces are filtered out. Over time sediment and other material can accumulate within the stone reservoir, depleting the area needed to store runoff until it can infiltrate adjacent soil. For trenches receiving surface runoff, the flow of stormwater should pass through 20 feet or so of thick grass to reduce sediment entry. Some trenches even have a sediment deposition area known as a forebay. Most trenches are designed to treat the first inch of runoff from the rooftops, streets and other impervious surfaces they service. The trench should drain completely within 48 hours following the end of runoff.

One of the ways of differentiating the various types of infiltration trenches is whether the stone is exposed at the surface or if it buried beneath a grass. A grass-covered trench is pictured here. The only visible feature is an observation well. ***You should never remove the cap from an observation well***. This makes it just about impossible to assess this type of trench.

ASSESSING INFILTRATION TRENCH CONDITION

1. Is a forebay or other pretreatment measure present?
   a. If **yes**, then does the pretreatment measure meet the criteria set forth at the end of the *Forebays & Other BMP Pretreatment Measures* factsheet?

Sediment from parking lot (right) captured in forebay (center) to protect infiltration trenches (left)

   b. If **no**, then are sediment accumulations visible between the surface stones?

Gravel surface and stone interstices free of sediment

2. If soil is exposed to erosive forces within the area draining to an infiltration trench, then the soil should be mulched-seeded as quickly as possible and runoff diverted away from the trench in the meantime.

Exposed soil, like that above this bioretention BMP, can quickly kill an infiltration trench

3. An infiltration trench needs maintenance if:
   a. Cattails or other wetland vegetation are present;

Winter view of cattails in trench indicating runoff no longer infiltrates completely within 48 hours

Summer view of cattails growing from trench

   b. Is other vegetation growing from the middle of the stone, indicating that portion of trench has filled with sediment;
   c. Water is visible between the surface stones more than 48 hours following a storm, or

Standing water present in trench more than 48 hours after runoff ended

   d. The trench overflows with runoff when less than an inch of rain falls in a 24-hour period.

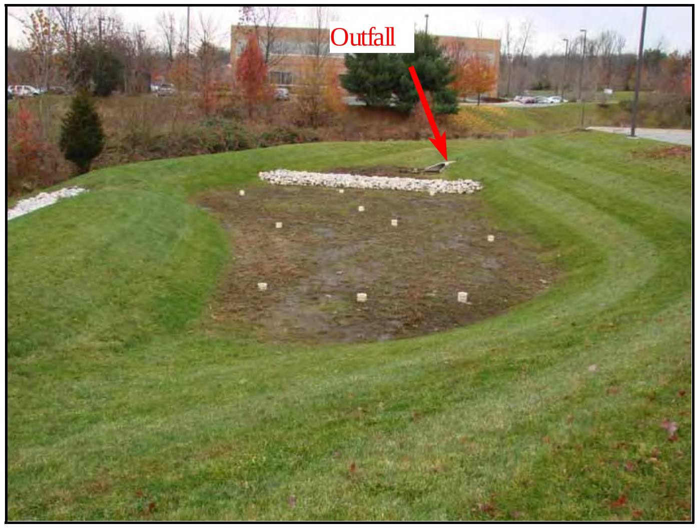
ASSESSING SAND FILTERS

As the name implies, this Best Management Practice (BMP) filters pollutants as stormwater runoff infiltrates through a two- or three-foot layer of sand. Sand filters are moderately effective measures for keeping stormwater pollution out of nearby waterways. The filters are usually constructed on sandy or other permeable soils. But with an underdrain a sand filter can be installed on any soil.

On the other side of this factsheet you'll find a typical sand filter design from the *Maryland Stormwater Design Manual*. As shown to the left, a pit is excavated. A gravel drainage layer is placed on the bottom. Perforated plastic pipe are then placed on the gravel. More gravel is added to cover the pipes. This is then covered with a "bridging" material then two- or three-feet of sand. The filter should hold water no more than a day or two after each storm, thus negating mosquito problems. A distinctive feature of sand filters are the numerous white PVC caps usually present, some of which are mostly clean-outs.

Sand filter overgrown with Phragmites & other wetland plants

Same overgrown sand filter as it looks in winter



Sand Filter with PVC clean-outs; checkdam forebay to capture sediment discharged from storm drain outfall in upper right

Over time sediment and other material can accumulate on the sand filter surface which can deplete the area needed to store runoff or the sediment can cause the filter surface to clog. Most sand filters will have a pretreatment system such as a forebay. If it appears that more than half the forebay original volume has been lost then it needs cleaning

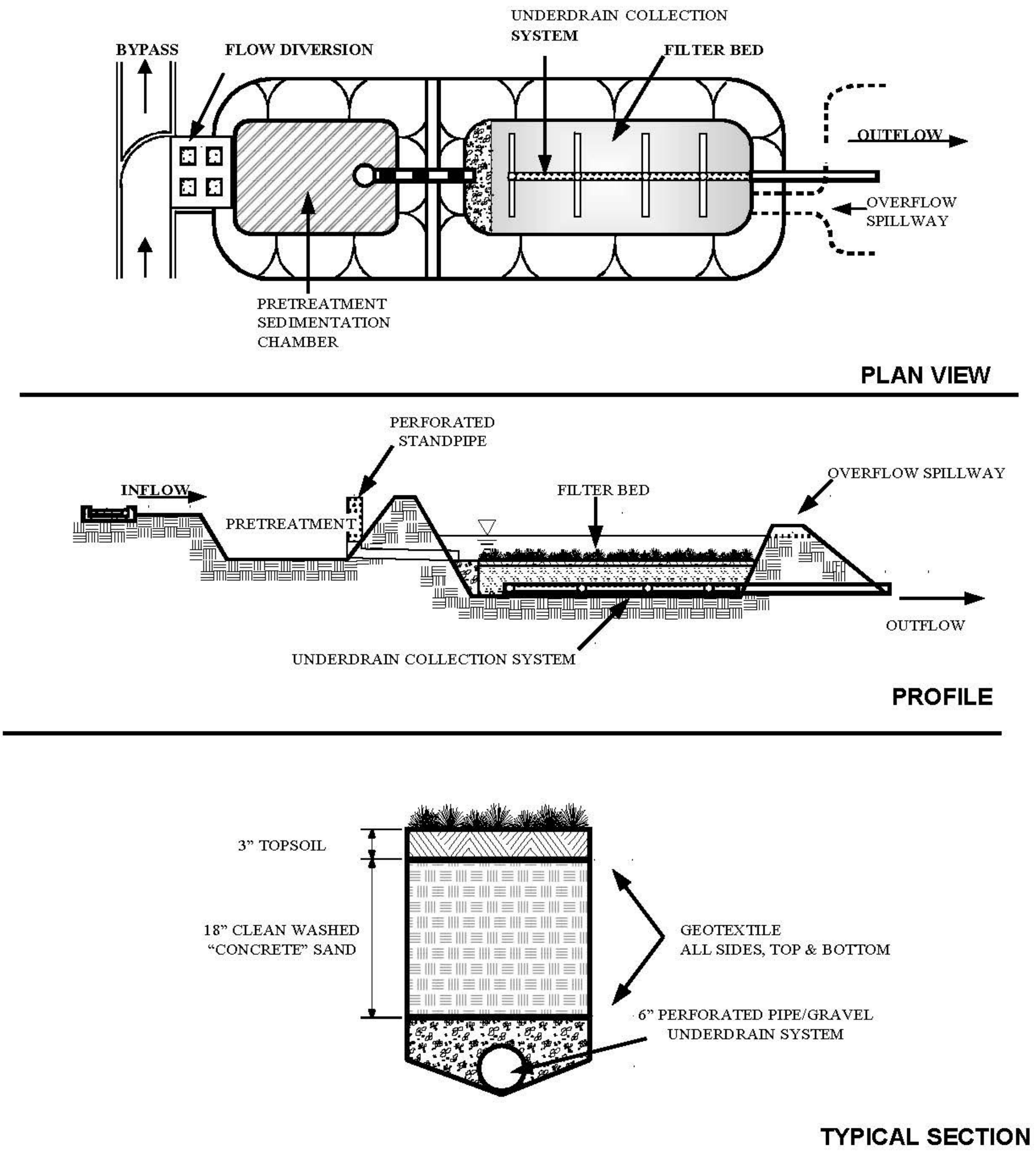
ASSESSING SAND FILTER CONDITION

1. Note if soil is exposed to erosive forces within the area draining to a sand filter. The soil should be mulched-seeded as quickly as possible and runoff diverted away from the trench in the meantime.

2. Consult the *Forebays & Other BMP Pretreatment Measures* factsheet to assess the conditions of any measures which may be present.

3. Note if any of these maintenance-needed indicators are present:
   a. Cattails or other wetland vegetation are present within the filter *(see photos to left)*;
   b. The filter bed is overgrown with vegetation;
   c. Sediment has moved into the filter area or the forebay is more than half full of sediment;
   d. Standing water is present on the surface more than 48 hours following a storm;
   e. The filter overflows at the spillway when less than an inch of rain falls in a 24-hour period; or
   f. The side slopes are eroding or the BMP is overgrown with vegetation.

F-1	**Figure 3.12** Example of Surface Sand Filter	F-1



Surface sand filters can treat the largest drainage area of all the filtering systems.

ASSESSING SWALES

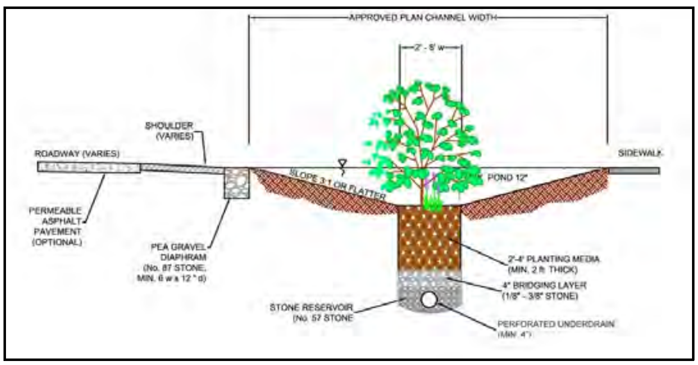
Grass Channels, Dry Swales, Bio Swales & Wet Swales

Dry or Bio Swales are among our most effective stormwater Best Management Practices (BMPs). At first glance a grass channel, dry swale or bio swale look much the same. But there are very big differences when it comes to aquatic resource protection. A grass channel is simply carved from native soil then planted with grass. But Dry, Bio and Wet Swales are engineered to be far more effective.

A Dry or Bio Swale from City of Southfield, MI

Dry & Bio Swales

The Dry and Bio Swale are essentially the same. Both are constructed by first excavating a long trench three- to five-feet deep. The length is generally equal to that of the impervious surface draining to the BMP, which is frequently a road or parking lot.



Environmental Site Design Bio Swale Cross-Section View from 2000 Maryland Stormwater Design Manual

As shown above, a perforated pipe underdrain may be placed at the bottom of the trench then covered with stone. A bridging layer is placed on top of the stone to prevent the next layer - sand/organic matter mix - from filling the stone interstices. The surface is planted in grass but may be landscaped with shrubs, trees, etc.

As runoff flows down the Bio Swale it soaks through the grass and into the sand layer where 70% to 80% of nutrients and sediment are removed. These pollutants are then stored well below the surface which prevents resuspension or erosion during future runoff events.

Why Dry & Bio Swales Are Better Than Grass

While grass channels can capture 10% to 70% of the pollutants, some are held mostly in the upper half-inch of soil at the channel surface. During mild storm events you may see that all the runoff entering the head of the channel soaks into the grass with little coming out the bottom. It is during these events that grass channels are most effective. But during major storms most runoff will discharge from the channel. Plus the high-velocity, turbulent runoff from these storms will resuspend or erode pollutants deposited in surface soils during milder storms. By storing pollutants well below the surface, the Dry or Bio Swale are far more effective in retaining pollutants and protecting aquatic resources.

Wet Swales

This BMP is installed in areas where the water table rises close to the land surface. Like other swales, it is a long channel. During the late winter-spring months when the water table is highest the bottom of the swale will be wet. By October it may be dry most of the time, except during runoff periods. Check dams may be installed along the swale to temporarily detain runoff which enhances pollutant removal. But since pollutants are mostly retained at the surface and little filtration is provided, Wet Swales only retain 20% to 40% of the nutrient load.

Wet swale along highway in Worcester County, MD

Assessing Grass Channels, Dry, Bio & Wet Swales
It can be hard to tell whether a facility is the old variety of grass ditch or a Grass Channel, Dry or Bio Swale. If you're looking at a roadside swale in an area developed before the 1990s, then its probably a grass ditch, like that pictured to the right. Newer channels that have a bottom width of two- to eight feet are probably a Grass Channel, Dry or Bio Swale. Following are the points to assess for these BMPs.

Conventional Grass Ditch Along Street

1. A forebay or other measures should be present to keep sediment from entering the BMP. Consult the *Forebays & Other BMP Pretreatment Measures* factsheet for items to check, such as:
   a. Is a forebay more than 50% full of sediment;
   b. Does sediment occupy more than 25% of a grass filter strip;
   c. Are the spaces between stones in a gravel diaphragm filled with sediment; or
   d. Has sediment been deposited within the Channel or Swale?

2. Is there any exposed soil in the area draining to the BMP? These soils should be stabilized quickly with straw mulch then grass or tarps if a storm is imminent.

Grass Channel from Montgomery Co, MD DEP

3. Are the side slopes of the channel-swale eroding? If yes, then these areas must be stabilized too.

4. Is the facility overgrown with vegetation?

5. For Grass Channels, Dry or Bio Swales, do you see indications that the facility has not drained completely within 48 hours when runoff last ended, such as:
   a. Wetland vegetation;
   b. Standing water; or
   c. Saturated surface soils?

6. For Wet Swales, has sediment accumulated within the channel?

Dry Swale from Chesapeake Stormwater Network

ASSESSING STORMWATER PONDS

Ponds are the most numerous stormwater Best Management Practices (BMPs) in Maryland. Ponds account for 43% of all our BMPs. There are six types of ponds: Dry Pond; Shallow Marsh; Extended-Detention Dry Pond; Extended-Detention Wet Pond; Wet Pond; and Infiltration Basin.

The first three are relatively ineffective with regard to aquatic resource protection and will not be addressed further. This factsheet applies to any pond designed to retain a permanent pool of water, which includes Extended-Detention Wet Ponds and Wet Ponds. Infiltration Basins are among ***THE*** most effective measures we have and are treated in a separate factsheet.

Stormwater Pond Basics

The intent of stormwater ponds is to manage runoff from homes, buildings, parking lots, streets and other *impervious* surfaces. Converting a forest to homes can increase runoff (floodwater) volume by two- or three-fold. Ponds are designed to store the difference in runoff volume then release it gradually to prevent downstream flooding and stream channel erosion. Also, a tremendous amount of pollution settles on rooftops and streets, then washes downstream with each storm event. If a pond contains a permanent pool of water then it can trap 20% to 60% of the nutrients and sediment entrained in runoff.

Vegetation Myth

The Wet Pond pollutant removal mechanism is mostly settling. So, the greater the pond volume, the higher pollutant removal will be. Anything that reduces pond volume, like cattails and other wetland vegetation, also reduces pollutant removal. While vegetation may take up some pollutants during the growing season, a substantial part of the uptake is released when the vegetation dies and decays over the winter.

Stormwater Wet Pond from Fairfax County, VA

Wet Pond Pool Volume: Over time the pool of water in a wet pond will fill with sediment then wetland vegetation, both of which rob pollutant storage capacity. During your assessment of this BMP, estimate the percent reduction in the original Wet Pond surface area which has occurred. Usually you can guesstimate where the original shoreline was by just looking at a pond. Using online sites such as Google Earth, compare the open water area of the pond today with that shown on older photos.

Wet Pond Partially Full With Sediment-Cattails

Dam Condition: Most ponds are created by placing an earth embankment across a shallow valley. The earth embankment should be free of trees and animal (groundhog) burrows, both of which could lead to dam failure. While viewing the dam from a distance, the top should appear as a straight, level surface. There should not be any low points, except for those ponds with an emergency spillway. Other low points may indicate settlement that could lead to dam failure. There should not be any wet spots or wetland vegetation on the dam.

Mowing

The earth embankment must be kept free of animal burrows and trees. Mowing is the best way to achieve this goal. Keeping an embankment in grass also makes it easier to inspect the dam for low-spots, wet spots and other conditions which may lead to failure.

Assessing Stormwater Ponds

1. If soil is exposed to erosive forces within the area draining to a Wet Pond, then the soil must be mulched-seeded as quickly as possible and runoff diverted away from the basin in the meantime.

2. What percentage of the original pond surface area is now occupied by vegetation, sediment, etc.?

3. Is a forebay or other pretreatment measure present?
   a. If **yes**, then does the pretreatment measure meet the criteria set forth at the end of the *Forebays & Other BMP Pretreatment Measures* factsheet?
   b. Are sediment deposits visible within the Basin; or
   c. Are gullies, exposed soil or other signs of erosion present on the Pond side slopes?

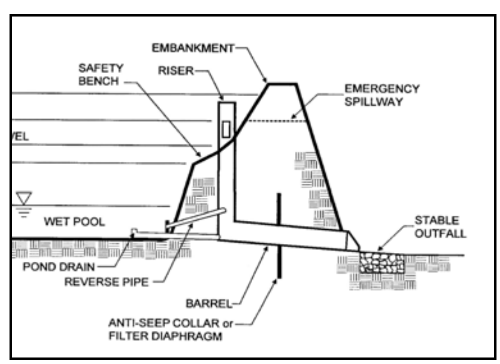
4. If the Wet Pond has an earth embankment then check it for:
   a. Low spots;
   b. Animal burrows;
   c. Trees growing on the embankment;
   d. Wet spots; or
   e. Wetland vegetation.

5. Is the embankment overgrown with vegetation, making it difficult to detect low-spots, burrows, etc.?

Straight, Level Earth Embankment; No Low Spots; No Trees or Burrows on Embankment

Groundhog burrow

No trees on dam embankment



Sideview of Pond Embankment

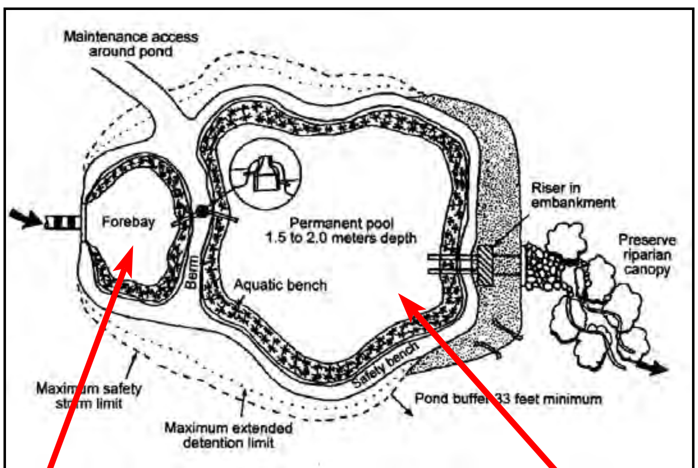
Keeping sediment and other debris out of ponds, filters and other stormwater Best Management Practices (BMPs); that's the purpose of forebays, filter strips, diaphragms, etc. These measures are usually located upslope of the BMPs so runoff first enters the pretreatment measure where sediment is trapped.

Pretreatment Measure Assessment, In General

If you see that a pretreatment measure is allowing sediment to reach the main part of a BMP then it must be cleaned and restored to its original condition. Usually you can guesstimate the original surface area. If you have difficulty then try looking at old aerial photos of the facility, like those on Google Earth, Terraserver, the Maryland MERLIN site, etc.

Forebay

Think of these measures as a little pond at the head of a big pond. The forebay provides a location where sediment can settle from suspension before entering the main BMP. The forebay must be cleaned when it has lost 50% of the original storage volume.



Forebay on left receiving runoff before it enters permanent pool from Maryland Stormwater Design Manual

Filter Strip

The design for infiltration trenches, bioretention facilities and other smaller BMPs will frequently call for a minimum 20-foot long grass filter strip immediately upslope. The strip must be wide enough to contain all incoming runoff. Sediment trapping in a filter strip is maximized when the strip is flat which forces runoff to flow through the strip in a shallow sheet between grass blades. Occasionally, a device known as a Level Spreader will be placed at the head of the strip to increase the likelihood of sheet flow. Filter strips must be cleaned when sediment accumulation has reduced the storage volume by 25% of more. If other pretreatment measures are present then the grass strip can be shortened.

Filter strip between building on right and bioretention center

Gravel Diaphragm

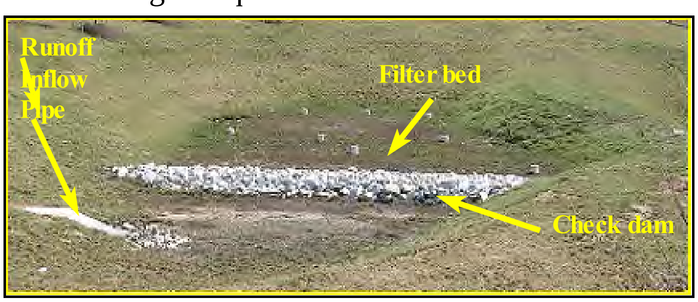
This pretreatment measure consists of a trench which usually surrounds a BMP but may only be present where runoff from an impervious surface enters the facility. The trench is typically at least six inches wide and twelve inches deep. The trench is filled with gravel the size of peas then ranging up to two-inches in diameter. The Gravel Diaphragm usually encircles the BMP though it may only be present between the impervious surface the BMP it serves. Some Gravel Diaphragms extend across the entire side slope of a BMP. The idea is that sediment suspended in runoff

White stone gravel diaphragms along both sides of bioretention will be trapped between the gravel as it flows over and into the diaphragm. All too frequently runoff will cross the diaphragm at a small percentage of its length. The gravel quickly fills with sediment at this point of concentrated flow which then eliminates protective benefits. If you find that the spaces between gravel is filled with sediment then the diaphragm likely requires cleaning. If there's vegetation growing from the gravel in the middle of the diaphragm then this may mean enough sediment has accumulated within the gravel to support vegetation. Again, cleaning is likely required.

Spaces between gravel clogged with sediment

Check Dam

Occasionally a row of earth, stone or rock will be found across sand filters and other BMPs. This check dam will be located between the point where runoff enters and the overflow (outfall) point. The check dam may serve two purposes: 1) to ensure runoff enters the sand filter in a shallow, sheet flow and/or 2) to prevent sediment from reaching the filter surface. If sediment is reaching the filter surface or substantial sediment accumulation has occurred upslope of the check dam, then cleaning is required.



Check dam separating runoff inflow (lower left) from sand filter

Sand Layer

Occasionally you will find a layer of sand over the bottom of an Infiltration Basin. The sand layer is intended to prevent sediment and other particles from reaching, then clogging the soil surface of the Basin floor. When a significant amount of sediment accumulates on the sand then it is removed and replaced with clean sand.

Assessing Pretreatment Measures

1. If a pretreatment measure is present and sediment has entered the BMP it serves, then the measure requires maintenance regardless whether the following criteria are met.

Sediment discharged into bioretention facility from Stormwater Maintenance LLC

2. If a forebay has lost 50% or more of the original surface area then it must be restored.

3. If sediment occupies more than 25% of a grass filter strip then maintenance is required.

4. If the spaces between the gravel in a diaphragm are filled with sediment or vegetation grows from the middle, then the diaphragm likely requires maintenance.

5. If a sand layer is present on the floor of an Infiltration Basin, then has sediment or other particles accumulated on the surface? If yes, then cleaning may be required.

Attachment B: BMP Flash Cards

KEY ASSESSMENT POINTS: BIORETENTION, MICRO-BIORETENTION & RAIN GARDENS

The three BMPs are essentially the same with regard to assessment procedures.

Typical facility in Good condition viewed from inlet end

Same BMP as to left but viewed from outlet end

Parking lot surface runoff enters here.

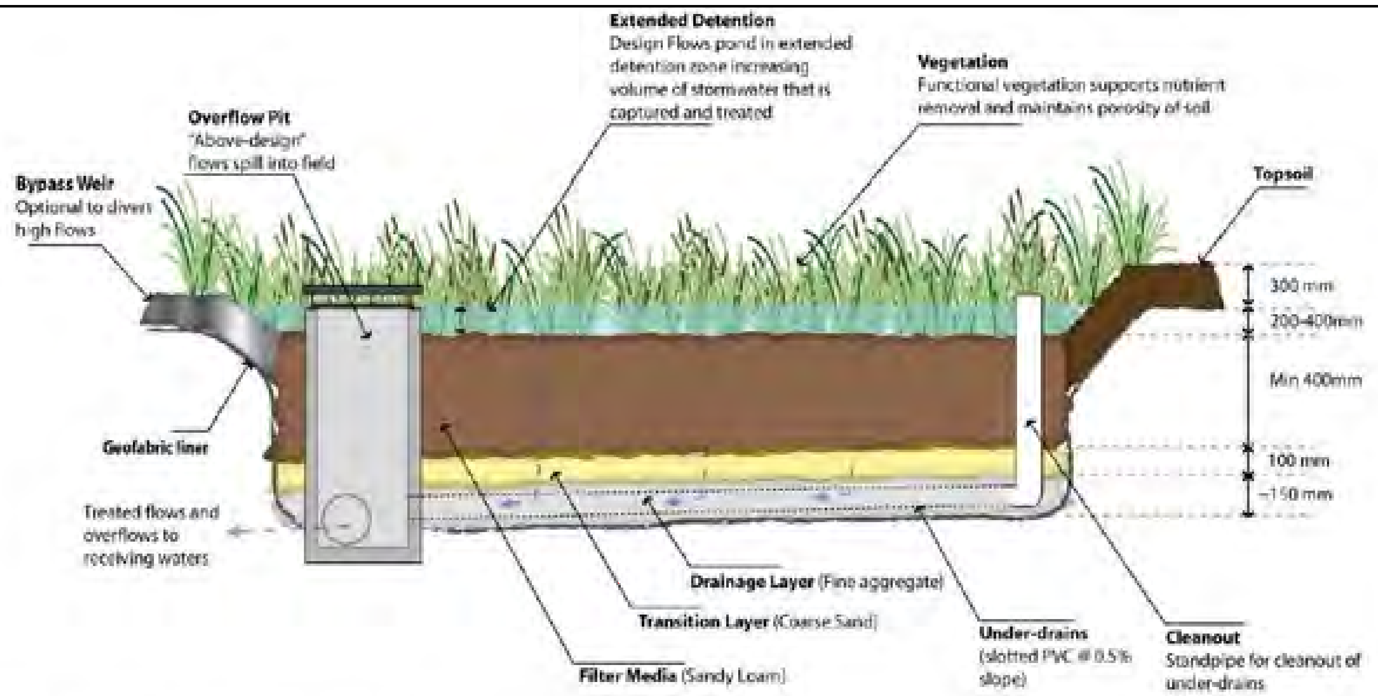
Runoff from storm drains discharges here.

Stone diaphragm.

Observation well

Outlet: First point where runoff can flow from facility.

Estimate freeboard height; inches from BMP floor to Outlet opening.



(Construction and Establishment Guidelines V1.1 April 2010; Image 3.1, Typical cross section through a bioretention system)

Gravel diaphragm adjoins both sides of bioretention BMP

Gravel diaphragm adjoins both sides of bioretention BMP

Clean gravel diaphragm

Clogged diaphragm

Standing water

Clogged Diaphragm

Cattails or other wetland plants

Winter view of cattails

2"-3" wood mulch on floor

V-Notch cut to prevent ponding

Hole drilled through inlet wall

KEY ASSESSMENT POINTS: INFILTRATION BASIN


Infiltration basin with no apparent outlet; just two observation wells


Infiltration basin with infiltration trench extending from spillway

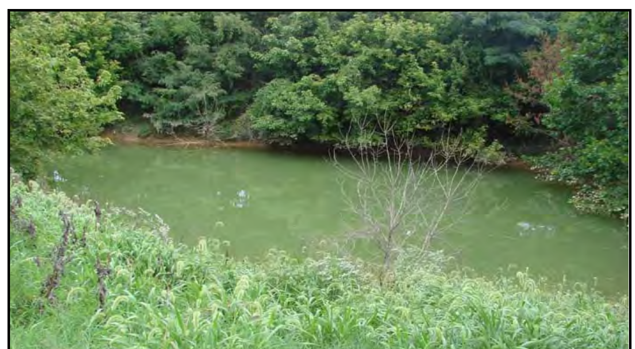

Infiltration basin with multiple, square infiltration pits like upper-right inset





Of the four outlets, only the left two serve infiltration basins. Note that the lowest opening on both of these spillways is at least a foot or two above the basin floor, which forces most runoff to infiltrate through the basin flood. Opening at bottom of the second from right outlet prevents ponding and infiltration. A perforated pipe buried in the stone drains runoff entering far right pond.

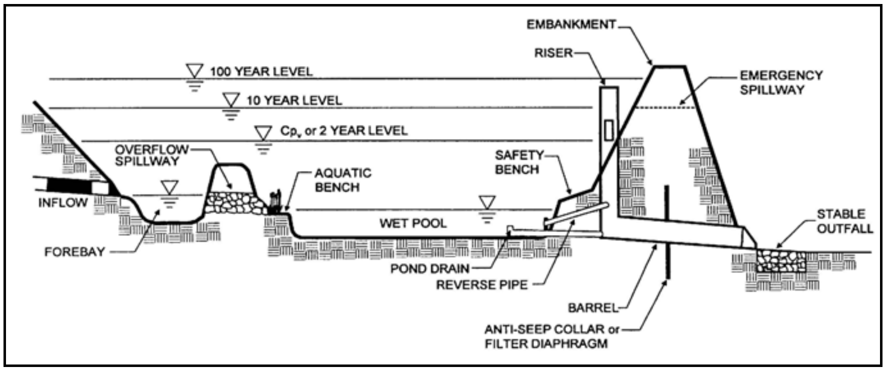

Infiltration basin is failing if water remains on the floor or in trench when 48 hours has passed since runoff ceased entering basin.


This infiltration basin holds a permanent pool of water


Infiltration Basin full of cattails


Infiltration Basin overgrown with vegetation

KEY ASSESSMENT POINTS: EARTH EMBANKMENT PONDS



Cross Section (profile) view of earth embankment stormwater wet pond

Pond created by placing earth embankment across a valley

Straight, level earth embankment; No low spots; No trees or burrows on embankment; Arrows point to embankment top, not low-spots

Emergency spillway; an intentional embankment low spot

Regular embankment mowing eases assessment

No animal burrows on dam

No wetland plants on dam

No trees on embankment

KEY ASSESSMENT POINTS: INFILTRATION TRENCH

Infiltration Trench with exposed stone; most common type

Infiltration Trench beneath lawn; only well visible; can't be assessed

Infiltration Trench beneath parking lot; only well/cleanout covers visible; can't be assessed

Spaces between stone free of sediment-water

Spaces between stone full of water

Spaces between stone full of sediment

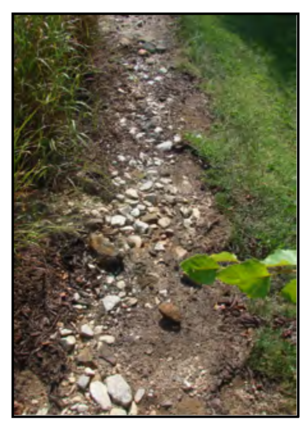
Cattails growing from saturated trench - winter view

Cattails growing from saturated trench - summer view

Observation wells

Grass filter strip full of sediment

Clean gravel diaphragm



Clogged diaphragm

KEY ASSESSMENT POINTS: WET PONDS

Typical Wet Pond

Micropool Wet Pond

When looking at a pond like this you can easily guess where the original shoreline was - where the mown grass meets the cattails. Over time sediment will accumulate within a pond which will then be colonized with wetland vegetation. If this process has significantly reduced the water surface area then the pond should be cleaned. Vegetation is not an asset; it lowers pollutant removal.

See other side for additional assessment points

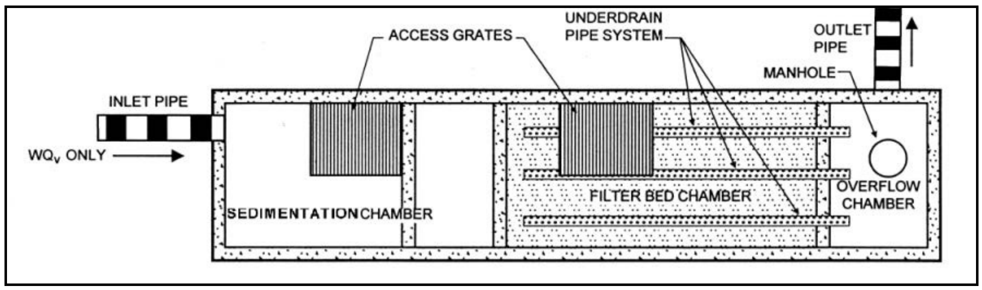
KEY ASSESSMENT POINTS: SAND FILTER

Sand Filter with PVC clean-outs; checkdam forebay for pretreatment

Grass covered sand filter; filter strip for pretreatment

Underground sand filter; very difficult to assess

Sand filter underdrains



Overhead view of underground sand filter

Sand filter overgrown with Phragmites, a wetland plant indicating clogging and that runoff no longer drains completely in 72 hours

Holding water more than 72 hours after runoff ceases indicates clogging and failure

Grass height in sand filter must not exceed 12; mow minimum three times per year

KEY ASSESSMENT POINTS: GRASS CHANNEL & DRY- OR BIO SWALES

Distinguishing these swale types can be difficult, but the assessment criteria is the same for both.

Cross-Section view of Dry or Bio Swale; engineered soil layers greatly enhances pollutant removal and recharge

A grass channel lacks the layers; its just a wide, flat channel created on native soil, but far more runoff infiltrates along this channel compared to a roadside ditch.

Typical roadside ditch; though runoff from lesser storms infiltrates through ditch bottom a large portion of runoff discharges to a nearby waterway

Some swales, particularly those with steeper slope, have stone, wood or concrete check dams to enhance infiltration

Sediment accumulated behind check dam must be periodically removed

Swales must be mowed at least twice a year to prevent overgrowth of weeds

Swale is failing if water does not drain completely within 48 hours after runoff ceases

Swale full of sediment; overgrown with vegetation with poor erosion control properties; severe erosion at outlet

Attachment C: BMP Checklists

BIORETENTION, MICRO-BIORETENTION & RAIN GARDENS
GREATER BALTIMORE SURVEY STORMWATER BMP CHECKLIST 2015

ID:____________________________ Site Name:____

Date:______________________ Your Initials:__________ Photos Taken:_______________________________________

BMP Presence: ☐ Not Found ☐ Not visible from public areas Other:_____________________________________

Location accurate: ☐ Yes ☐ No If no, GPS reading: W______________________ N_________________________

Or describe location:____

BMP Type Code: ☐ Same as ID **Actual BMP type:** ☐ Bioretention(b) ☐ Infiltration Basin(i)

☐ Infiltration Trench(t) ☐ Rain Garden (g) ☐ Sand Filter(f) ☐ Pond(p) ☐ Microbioretention(m) ☐ Swale(s)

Overall BMP Condition: ☐ Good ☐ **Maintenance Needed** ☐ **Failing** ☐ Uncertain

Only check one of these four boxes: If one or more red boxes are checked below than BMP is Failing; If no red boxes checked, but one or more green boxes are checked than Maintenance Needed.

APPEARANCE

1. Is the facility free of dead, dying or invasive vegetation: . . . . ☐ Yes ☐ No
2. Is the facility free of trash or other debris: . . . . ☐ Yes ☐ No
3. With regard to visual appearance, would you want this BMP next to your home? . . . . ☐ Yes ☐ No

FACILITY DRAINAGE AREA

4. Is the facility and the area draining to the facility free of soil erosion: . . . . ☐ Yes ☐ **No**
   If no or uncertain, describe in Comments.
5. Can runoff clearly flow into the BMP from rooftops, streets, parking lots
   or other impervious (*If no or uncertain, describe in Comments*) . . . . ☐ Yes ☐ **No** ☐ Uncertain

PRETREATMENT

6. Pretreatment measures present: ☐ Yes, check those present below ☐ No, go to 11, below
7. ☐ Forebay: Does sediment occupy 50% or more of the original forebay capacity: . . . . ☐ **Yes** ☐ No
8. ☐ Grass Filter Strip: Length______ ft Does sediment cover 25% or more of strip length: . . . ☐ **Yes** ☐ No
9. ☐ Gravel Diaphragm:
   a. Does runoff enter uniformly along entire length of the gravel diaphragm: . . . . ☐ Yes ☐ No
   b. Is runoff entry concentrated at one or several points: . . . . ☐ Yes ☐ No
   c. Are spaces between gravel full of sediment: . . . . ☐ **Yes** ☐ No
   d. Is vegetation growing from center of gravel: . . . . ☐ **Yes** ☐ No
10. Other:______________________________Does the other measure need cleaning; . . . . ☐ **Yes** ☐ No
11. Is sediment getting through to the BMP: . . . . ☐ **Yes** ☐ No
    a. If yes, percent of BMP floor covered with sediment: . . . . __________%

MAIN FACILITY

12. What is the depth between the BMP surface and the first point where runoff could exit:. . . . . ______inches
    If less than six then we'll do additional analyses to verify adequate capacity.
13. Do you see any holes, notches or other spillway modifications to reduce ponding:. . . . . ☐ Yes ☐ No
14. Has it been more than 48 hours since runoff from the last storm ended:. . . . . ☐ Yes ☐ No
    a. If yes, then is water visible on the BMP surface:. . . . . ☐ Yes ☐ No
15. Are cattails or other wetland vegetation growing from the BMP:.. . . . . ☐ Yes ☐ No
16. Is the BMP floor covered with:
    a. Two- or three-inches of wood mulch:. . . . . ☐ Yes ☐ No
    b. Mulch is present, but mulch depth is less than two- or three-inches. ☐ Yes ☐ No
    c. Mown grass:. . . . . ☐ Yes ☐ No
    d. Other vegetation which appears the result of careful landscaping:. . . . . ☐ Yes ☐ No
    e. Weeds, shrubs and other overgrowth:.. . . . . ☐ Yes ☐ No
    f. Nothing; underlying soil is fully exposed with no covering:.. . . . . ☐ Yes ☐ No
    g. Other:____
17. Are observation wells present:.. . . . . ☐ Yes ☐ No
    a. If yes, then is a cap in place on each well:. . . . . ☐ Yes ☐ No
18. Do you see any evidence of soil erosion on the BMP side slopes:.. . . . . ☐ Yes ☐ No
19. Do you see any other problem indicators:. . . . . ☐ Yes ☐ No
    a. If you checked Yes, then describe in Comments below.

Go back to the beginning of this form and rate the overall condition of this BMP.

COMMENTS & OTHER ITEMS NOTED

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INFILTRATION BASIN

GREATER BALTIMORE SURVEY STORMWATER BMP CHECKLIST 2015

ID:__________________________ Site Name:____

Date:____________________ Your Initials:__________ Photos Taken:___________________________________

BMP Presence: ☐ Not Found ☐ Not visible from public areas Other:________________________________

Location accurate: ☐ Yes ☐ No If no, GPS reading: W_____________________ N______________________

Or describe location:____

BMP Type Code: ☐ Same as ID **Actual BMP type:** ☐ Bioretention(b) ☐ Infiltration Trench(t)
☐ Rain Garden (g) ☐ Sand Filter(f) ☐ Pond(p) ☐ Microbioretention(m) ☐ Swale(s)

Overall BMP Condition: ☐ Good ☐ Maintenance Needed ☐ Failing ☐ Uncertain

Only check one of these four boxes: If one or more red boxes are checked below than BMP is Failing; If no red boxes checked, but one or more green boxes are checked than Maintenance Needed.

APPEARANCE

1. Is the facility free of dead, dying or invasive vegetation:. . . . . ☐ Yes ☐ No
2. Is the facility free of trash or other debris:. . . . . ☐ Yes ☐ No
3. With regard to visual appearance, would you want this BMP next to your home?. . . . . ☐ Yes ☐ No

FACILITY DRAINAGE AREA

4. Is the facility and the area draining to the facility free of soil erosion:.. . . . . ☐ Yes ☐ No
   If no or uncertain, describe in Comments.
5. Can runoff clearly flow into the BMP from rooftops, streets, parking lots
   or other impervious (*If no or uncertain, describe in Comments*) . . . . ☐ Yes ☐ No ☐ Uncertain

PRETREATMENT

6. Pretreatment measures present: ☐ Yes, check those present below ☐ No, go to 12, below
7. ☐ Forebay: Does sediment occupy 50% or more of the original forebay capacity:. . . . . ☐ Yes ☐ No
8. ☐ Grass Filter Strip: Length_____ ft Does sediment cover 25% or more of strip length:. . . . . . ☐ Yes ☐ No
9. ☐ Gravel Diaphragm:
   a. Does runoff enter uniformly along entire length of gravel diaphragm:. . . . . ☐ Yes ☐ No
   b. Is runoff entry concentrated at one or several points: . . . . ☐ Yes ☐ No
   c. Are spaces between gravel full of sediment: . . . . ☐ Yes ☐ No
   d. Is vegetation growing from center of gravel:. . . . . ☐ Yes ☐ No
10. ☐ Sand Layer covering BMP surface. . . . . ☐ Yes ☐ No
    a. What percent of sand layer is covered with sediment or other matter.. . . . . __________%
11. Other:___________________________Does the other measure need cleaning;. . . . . ☐ Yes ☐ No
12. Is sediment getting through to the BMP:. . . . . ☐ Yes ☐ No
    a. If yes, percent of BMP floor covered with sediment:. . . . . __________%

13. Is the Basin preceded by a Water Quality Treatment measure:.. ☐ Yes ☐ No

If yes, then note the type below but assess using the appropriate form.

a. Sand filter:. ☐ Yes ☐ No

b. Bioretention:.. ☐ Yes ☐ No

c. Other: ____________________

14. Do you see any evidence that the Basin floor was ever covered with sand:.. ☐ Yes ☐ No

a. If yes, then is the sand free of sediment and other particles:. ☐ Yes ☐ No

15. What is the depth between the Basin floor and the first runoff entry point on the spillway:. ________ft

16. Has it been more than 48 hours since runoff ended from the last storm:. ☐ Yes ☐ No

a. If yes, then is water present within the Basin:.. ☐ Yes ☐ No

17. Are cattails or other wetland vegetation present within the Basin:.. ☐ Yes ☐ No

18. What type of vegetation covers the Basin floor:

a. Mown grass:.. ☐ Yes ☐ No

b. Taller grass:. ☐ Yes ☐ No

c. Overgrown with weeds, shrubs or trees:. ☐ Yes ☐ No

d. Other: ____________________

19. Is an Infiltration Trench present within the Basin:. ☐ Yes ☐ No

a. If yes, then is vegetation growing from the trench:. ☐ Yes ☐ No

b. Are the spaces between the trench stones filled with sediment or vegetation:. ☐ Yes ☐ No

20. Are observation wells present:.. ☐ Yes ☐ No

a. If yes, then is a cap in place on each well:. ☐ Yes ☐ No

21. Is an earth embankment present:. ☐ Yes ☐ No

a. If yes, then is embankment vegetation short enough to assess the following factors:. ☐ Yes ☐ No

b. Low spots along the embankment top, except for emergency spillways:. ☐ Yes ☐ No

c. Animal burrows:.. ☐ Yes ☐ No

d. Trees, shrubs or other woody vegetation:.. ☐ Yes ☐ No

e. Wet spots on downstream face of embankment:. ☐ Yes ☐ No

f. Wetland vegetation growing on downstream face of embankment:.. ☐ Yes ☐ No

g. Do you see rills, gullies or other soil erosion signs on pond side slopes or embankment:. ☐ Yes ☐ No

22. Do you see any other problem indicators:. ☐ Yes ☐ No

a. If you checked Yes, then describe in Comments below.

Go back to the beginning of this form and rate the overall condition of this BMP.

COMMENTS & OTHER ITEMS NOTED

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INFILTRATION TRENCH

Greater Baltimore Survey Stormwater BMP Checklist 2015

ID:________________________ Site Name:____

Date:__________________ Your Initials:_________ Photos Taken:_______________________________

BMP Presence: ☐ Not Found ☐ Not visible from public areas ☐ Beneath parking lot

Location accurate: ☐ Yes ☐ No If no, GPS reading: W___________________ N____________________

Or describe location:____

BMP Type Code: ☐ Same as ID **Actual BMP type:** ☐ Bioretention(b) ☐ Infiltration Basin(i)

☐ Rain Garden (g) ☐ Sand Filter(f) ☐ Pond(p) ☐ Microbioretention(m) ☐ Swale(s)

Overall BMP Condition: ☐ Good ☐ Maintenance Needed ☐ Failing ☐ Uncertain

Only check one of these four boxes: If one or more red boxes are checked below than BMP is Failing; If no red boxes checked, but one or more green boxes are checked than Maintenance Needed.

APPEARANCE

1. Is the facility free of dead, dying or invasive vegetation:. . . . . ☐ Yes ☐ No
2. Is the facility free of trash or other debris:. . . . . ☐ Yes ☐ No
3. With regard to visual appearance, would you want this BMP next to your home?. . . . . ☐ Yes ☐ No

FACILITY DRAINAGE AREA

4. Is the facility and the area draining to the facility free of soil erosion:.. ☐ Yes ☐ No
   If no or uncertain, describe in Comments.
5. Can runoff clearly flow into the BMP from rooftops, streets, parking lots
   or other impervious (*If no or uncertain, describe in Comments*) . . . . ☐ Yes ☐ No ☐ Uncertain

PRETREATMENT

6. Pretreatment measures present: ☐ Yes, check those present below ☐ No, go to 12, below
7. ☐ Forebay: Does sediment occupy 50% or more of the original forebay capacity:. . . . . ☐ Yes ☐ No
8. ☐ Grass Filter Strip: Length_____ ft Does sediment cover 25% or more of strip length:. . . . . . ☐ Yes ☐ No
9. ☐ Gravel Diaphragm:
   a. Does runoff enter uniformly along entire length of gravel diaphragm:. . . . . ☐ Yes ☐ No
   b. Is runoff entry concentrated at one or several points: . . . . ☐ Yes ☐ No
   c. Are spaces between gravel full of sediment: . . . . ☐ Yes ☐ No
   d. Is vegetation growing from center of gravel:. . . . . ☐ Yes ☐ No
10. ☐ Does a sand layer cover BMP surface. . . . . ☐ Yes ☐ No
    a. If yes, what percent of sand layer is covered with sediment or other matter.. . . . . _________%
11. Other:_________________________Does the other measure need cleaning;. . . . . ☐ Yes ☐ No

12. Is sediment getting through to the BMP:. . . . . ☐ Yes ☐ No

   a. If yes, percent of BMP floor covered with sediment:. . . . . ________%

MAIN FACILITY

13. What type of Infiltration Trench:.. . . . . ☐ Exposed Stone ☐ Grass Covered ☐ Beneath Parking Lot

14. Has it been more than 48 hours since runoff ended from the last storm:. . . . . ☐ Yes ☐ No

   a. If yes, then is water visible within the Trench:. . . . . ☐ Yes ☐ No

15. Are cattails or other wetland vegetation growing from the Trench:. . . . . ☐ Yes ☐ No

16. Is other vegetation growing from the center of the Trench:. . . . . ☐ Yes ☐ No

17. Can you see sediment filling the spaces between the stones in the Trench:. . . . . ☐ Yes ☐ No

18. Are observation wells present:.. . . . . ☐ Yes ☐ No

   a. If yes, then is a cap in place on each well:. . . . . ☐ Yes ☐ No

19. Do you see any other problem indicators:. . . . . ☐ Yes ☐ No

   a. If you checked Yes, then describe in Comments below.

Go back to the beginning of this form and rate the overall condition of this BMP.

COMMENTS & OTHER ITEMS NOTED

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WET POND

GREATER BALTIMORE SURVEY STORMWATER BMP CHECKLIST 2015

ID:__________________________ Site Name:____

Date:____________________ Your Initials:__________ Photos Taken:__________________________________

BMP Presence: ☐ Not Found ☐ Not visible from public areas Other:__________________________________

Location accurate: ☐ Yes ☐ No If no, GPS reading: W_____________________ N______________________

Or describe location:____

BMP Type Code: ☐ Same as ID **Actual BMP type:** ☐ Bioretention(b) ☐ Infiltration Basin(i)

☐ Infiltration Trench(t) ☐ Rain Garden (g) ☐ Sand Filter(f) ☐ Microbioretention(m) ☐ Swale(s)

Overall BMP Condition: ☐ Good ☐ Maintenance Needed ☐ Failing ☐ Uncertain

Only check one of these four boxes: If one or more red boxes are checked below than BMP is Failing; If no red boxes checked, but one or more green boxes are checked than Maintenance Needed.

APPEARANCE

1. Is the facility free of dead, dying or invasive vegetation:. . . . . ☐ Yes ☐ No
2. Is the facility free of trash or other debris:. . . . . ☐ Yes ☐ No
3. With regard to visual appearance, would you want this BMP next to your home?. . . . . ☐ Yes ☐ No

FACILITY DRAINAGE AREA

4. Is the facility and the area draining to the facility free of soil erosion:.. . . . . ☐ Yes ☐ No
   If no or uncertain, describe in Comments.
5. Can runoff clearly flow into the BMP from rooftops, streets, parking lots
   or other impervious (*If no or uncertain, describe in Comments*) . . . . ☐ Yes ☐ No ☐ Uncertain

PRETREATMENT

6. Pretreatment measures present: ☐ Yes, check those present below ☐ No, go to 11, below
7. ☐ Forebay: Does sediment occupy 50% or more of the original forebay capacity:. . . . . ☐ Yes ☐ No
8. ☐ Grass Filter Strip: Length_____ ft Does sediment cover 25% or more of strip length:. . . . . . ☐ Yes ☐ No
9. ☐ Gravel Diaphragm:
   a. Does runoff enter uniformly along entire length of gravel diaphragm:. . . . . ☐ Yes ☐ No
   b. Is runoff entry concentrated at one or several points: . . . . ☐ Yes ☐ No
   c. Are spaces between gravel full of sediment: . . . . ☐ Yes ☐ No
   d. Is vegetation growing from center of gravel:. . . . . ☐ Yes ☐ No
10. Other:___________________________Does the other measure need cleaning;. . . . . ☐ Yes ☐ No
11. Is sediment getting through to the BMP:. . . . . ☐ Yes ☐ No
    a. If yes, percent of BMP floor covered with sediment:. . . . . _________%

MAIN FACILITY

12. Is the pond preceded by a Water Quality Treatment measure:. . . . . ☐ Yes ☐ No

    If yes, then note the type below but assess using the appropriate form.

    a. Sand filter:. . . . . ☐ Yes ☐ No

    b. Bioretention:.. . . . . ☐ Yes ☐ No

    c. Other:____

13. Is a pool of open water present within the pond:. . . . . ☐ Yes ☐ No

    a. If yes, what percentage of the original open water surface area remains:.. . . . . _________%

14. Is an earth embankment present:. . . . . ☐ Yes ☐ No

    If yes, then:

    a. Is the vegetation on the embankment short enough to assess the following factors:. . . . . ☐ Yes ☐ No

    b. Low spots along the embankment top, except for emergency spillways:. . . . . ☐ Yes ☐ No

    c. Animal burrows:.. . . . . ☐ Yes ☐ No

    d. Trees, shrubs or other woody vegetation:.. . . . . ☐ Yes ☐ No

    e. Wet spots on downstream face of embankment:. . . . . ☐ Yes ☐ No

    f. Wetland vegetation growing on downstream face of embankment:.. . . . . ☐ Yes ☐ No

    g. Do you see rills, gullies or other soil erosion signs on pond side slopes or embankment:. . . ☐ Yes ☐ No

15. Do you see any other problem indicators:. . . . . ☐ Yes ☐ No

    a. If you checked Yes, then describe in Comments below.

Go back to the beginning of this form and rate the overall condition of this BMP.

COMMENTS & OTHER ITEMS NOTED

SAND FILTER

GREATER BALTIMORE SURVEY STORMWATER BMP CHECKLIST 2015

ID:_________________________ Site Name:____

Date:___________________ Your Initials:_________ Photos Taken:_________________________________

BMP Presence: ☐ Not Found ☐ Not visible from public areas ☐ Beneath parking lot

Location accurate: ☐ Yes ☐ No If no, GPS reading: W____________________ N_____________________

Or describe location:____

BMP Type Code: ☐ Same as ID **Actual BMP type:** ☐ Bioretention(b) ☐ Infiltration Basin(i)

☐ Infiltration Trench(t) ☐ Rain Garden (g) ☐ Pond(p) ☐ Microbioretention(m) ☐ Swale(s)

Overall BMP Condition: ☐ Good ☐ Maintenance Needed ☐ Failing ☐ Uncertain

Only check one of these four boxes: If one or more red boxes are checked below than BMP is Failing; If no red boxes checked, but one or more green boxes are checked than Maintenance Needed.

APPEARANCE

1. Is the facility free of dead, dying or invasive vegetation:. . . . . ☐ Yes ☐ No
2. Is the facility free of trash or other debris:. . . . . ☐ Yes ☐ No
3. With regard to visual appearance, would you want this BMP next to your home?. . . . . ☐ Yes ☐ No

FACILITY DRAINAGE AREA

4. Is the facility and the area draining to the facility free of soil erosion:.. . . . . ☐ Yes ☐ No
   If no or uncertain, describe in Comments.
5. Can runoff clearly flow into the BMP from rooftops, streets, parking lots
   or other impervious (*If no or uncertain, describe in Comments*) . . . . ☐ Yes ☐ No ☐ Uncertain

PRETREATMENT

6. Pretreatment measures present: ☐ Yes, check those present below ☐ No, go to 11, below
7. ☐ Sedimentation chamber: Has sediment accumulated to a depth of 6 inches or greater. . . . . . . ☐ Yes ☐ No
8. ☐ Grass Filter Strip: Length_____ ft Does sediment cover 25% or more of strip length:. . . . . . ☐ Yes ☐ No
9. ☐ Gravel Diaphragm:
   a. Does runoff enter uniformly along entire length of gravel diaphragm:. . . . . ☐ Yes ☐ No
   b. Is runoff entry concentrated at one or several points: . . . . ☐ Yes ☐ No
   c. Are spaces between gravel full of sediment: . . . . ☐ Yes ☐ No
   d. Is vegetation growing from center of gravel:. . . . . ☐ Yes ☐ No
10. Other:___________________________Does the other measure need cleaning;. . . . . ☐ Yes ☐ No
11. Is sediment getting through to the BMP:. . . . . ☐ Yes ☐ No
    a. If yes, percent of BMP floor covered with sediment:. . . . . _________%

MAIN FACILITY

12. Has it been more than 72 hours since runoff ended from the last storm:. . . . . ☐ Yes ☐ No
    a. If yes, then is water visible on the filter surface:. . . . . ☐ Yes ☐ No
13. Are cattails or other wetland vegetation growing from the filter:. . . . . ☐ Yes ☐ No
14. Is the filter covered by mown grass:. . . . . ☐ Yes ☐ No
15. Is other vegetation growing from the center of the filter:. . . . . ☐ Yes ☐ No
16. Is the sand covered by sediment or other particles:. . . . . ☐ Yes ☐ No
17. Are observation wells or clean-outs present:. . . . . ☐ Yes ☐ No
    a. If yes, then is a cap in place on each well or clean-out:. . . . . ☐ Yes ☐ No
18. Do you see any evidence of soil erosion on the filter side slopes:. . . . . ☐ Yes ☐ No
19. Do you see any other problem indicators:. . . . . ☐ Yes ☐ No
    a. If you checked Yes, then describe in Comments below.

Go back to the beginning of this form and rate the overall condition of this BMP.

COMMENTS & OTHER ITEMS NOTED

GRASS CHANNEL, DRY- or BIO-SWALES
GREATER BALTIMORE SURVEY STORMWATER BMP CHECKLIST 2015

ID:__________________________ Site Name:____

Date:____________________ Your Initials:__________ Photos Taken:__________________________________

BMP Presence: ☐ Not Found ☐ Not visible from public areas Other:___________________________________

Location accurate: ☐ Yes ☐ No If no, GPS reading: W_____________________ N______________________

Or describe location:____

BMP Type Code: ☐ Same as ID **Actual BMP type:** ☐ Bioretention(b) ☐ Infiltration Basin(i)

☐ Infiltration Trench(t) ☐ Rain Garden (g) ☐ Sand Filter(f) ☐ Pond(p) ☐ Microbioretention(m)

Overall BMP Condition: ☐ Good ☐ Maintenance Needed ☐ Failing ☐ Uncertain

Only check one of these four boxes: If one or more red boxes are checked below than BMP is Failing; If no red boxes checked, but one or more green boxes are checked than Maintenance Needed.

APPEARANCE

1. Is the facility free of dead, dying or invasive vegetation:. . . . . ☐ Yes ☐ No
2. Is the facility free of trash or other debris:. . . . . ☐ Yes ☐ No
3. With regard to visual appearance, would you want this BMP next to your home?. . . . . ☐ Yes ☐ No

FACILITY DRAINAGE AREA

4. Is the facility and the area draining to the facility free of soil erosion:. . . . . ☐ Yes ☐ No
   If no or uncertain, describe in Comments.
5. Can runoff clearly flow into the BMP from rooftops, streets, parking lots
   or other impervious (*If no or uncertain, describe in Comments*) . . . . ☐ Yes ☐ No ☐ Uncertain

PRETREATMENT

6. Pretreatment measures present: ☐ Yes, check those present below ☐ No, go to 11, below
7. ☐ Forebay: Does sediment occupy 50% or more of the original forebay capacity:. . . . . ☐ Yes ☐ No
8. ☐ Grass Filter Strip: Length_____ ft Does sediment cover 25% or more of strip length:. . . . . . ☐ Yes ☐ No
9. ☐ Gravel Diaphragm:
   a. Does runoff enter uniformly along entire length of gravel diaphragm:. . . . . ☐ Yes ☐ No
   b. Is runoff entry concentrated at one or several points: . . . . ☐ Yes ☐ No
   c. Are spaces between gravel full of sediment: . . . . ☐ Yes ☐ No
   d. Is vegetation growing from center of gravel:. . . . . ☐ Yes ☐ No
10. Other:___________________________Does the other measure need cleaning;. . . . . ☐ Yes ☐ No
11. Is sediment getting through to the BMP:. . . . . ☐ Yes ☐ No
    a. If yes, percent of BMP floor covered with sediment:. . . . . _________%

MAIN FACILITY

12. Has it been more than 48 hours since runoff ended from the last storm:. ☐ Yes ☐ No
    a. If yes, then is water visible on the Swale surface:. . . . . ☐ Yes ☐ No
13. Are cattails or other wetland vegetation growing from the Swale floor:. . . . . ☐ Yes ☐ No
14. Is there a point along the length of the swale where runoff would pond to a depth of 12 inches or more?. . . . . ☐ Yes ☐ No
    a. If no, then what is the maximum ponding depth?. . . . . ________ Inches
15. Is the Swale floor covered with:
    a. Grass:. . . . . ☐ Yes ☐ No
    b. If grass, then does it appear the grass is being mowed every couple of months or so:. . . . . . . ☐ Yes ☐ No
    c. Other vegetation which appears the result of careful landscaping:. . . . . ☐ Yes ☐ No
    d. Weeds, shrubs and other overgrowth:.. . . . . ☐ Yes ☐ No
    e. Nothing; underlying soil is partially or fully exposed with no covering:. . . . . ☐ Yes ☐ No
    f. Other: ____________________
16. Are check dams present:.. . . . . ☐ Yes ☐ No
    a. If yes, then do you see sediment accumulations above the check dams:. . . . . ☐ Yes ☐ No
    b. If you checked "yes" for 16a, what percent of the check dams have sediment accumulations:. ________%
17. Are observation wells present:.. . . . . ☐ Yes ☐ No
    a. If yes, then is a cap in place on each well:. . . . . ☐ Yes ☐ No
18. Do you see any evidence of soil erosion on the Swale floor or side slopes:. . . . . ☐ Yes ☐ No
19. Do you see any other problem indicators:. . . . . ☐ Yes ☐ No
    a. If you checked Yes, then describe in Comments below.

Go back to the beginning of this form and rate the overall condition of this BMP.

COMMENTS & OTHER ITEMS NOTED

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