Appendix 4 – Stormwater BMP Factsheets

FORESTED RIPARIAN BUFFER

Stormwater Best Management Practices

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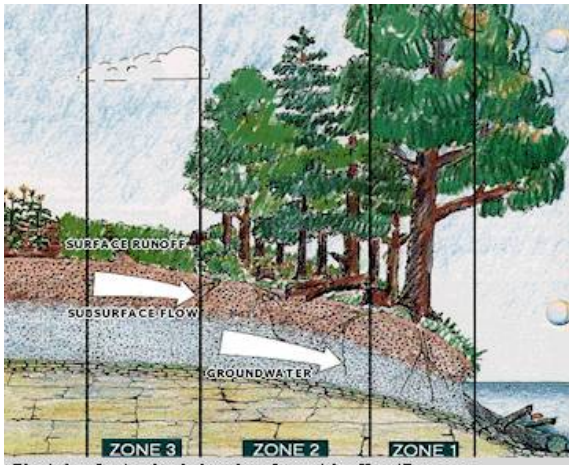
What is a forested riparian buffer?

A forested riparian buffer is a stretch of land that intercepts surface runoff and groundwater before reaching a body of water such as a stream, lake or wetland. It can help reduce pollution in the water body, provide stormwater management and can act as a floodway during major storm events. Buffer widths vary by slope and existing conditions.



Sketch of a typical riparian forest buffer (Source: Chesapeake Bay Program, 2000)

Are there other names for this type of system?

Yes, there are three types of buffers that make up this system. A forested riparian buffer may also be called a Water Pollution Hazard Setback, Vegetated Buffer or Engineered Buffer.

How is a forested riparian buffer designed?

Zone 1 is a minimum of 25 feet wide plus wetland and critical habitats. The typical vegetation in this zone is an established forest. **Zone 2** is typically 50 – 100 feet wide and the vegetation should be a managed forest. **Zone 3** is a minimum of 25 feet wide. The vegetation in this zone should be either a managed forest or turf-grass. With good design and conditions, buffer widths can be as narrow as soft. The slope of the buffer should be between 1% and 15%. One study performed by the California Stormwater Quality Association determined that the maximum width of the tributary area should be 60 ft. and the length should be equal to the buffer. This design standard is able to handle a 2 year-storm without altering its performance. Maintenance of vegetation s and banks may be necessary.

Are there any secondary uses for a forested riparian buffer?

Yes, but there are some restrictions on what you can put in each of the zones. **Zone 1** is only allowed to be used for flood control, utility right-of-ways or footpaths. **Zone 2** can be used for some recreational activities, some stormwater BMPs and bike paths. There are no restrictions for **Zone 3**.

How much does it cost to install and maintain a forested riparian buffer?

The actual amount to construct and maintain a riparian buffer is highly dependent on the length and width of the buffer and existing conditions. One study conducted in 2006 by the Chesapeake Bay Program determined that it would cost approximately $3,000.00 - $7,500.00 per acre to plant and maintain a forested riparian buffer.

Are there any special considerations?

A forested riparian buffer is effective at removing pollutants when the incoming stormwater runoff is evenly distributed along the buffer. If a channel were to be created in the buffer, large quantities of water would flow through the channel and not get filtered by the buffer. Special care should be taken so that channels do not form in the buffer and that the water is evenly dispersed throughout the buffer.

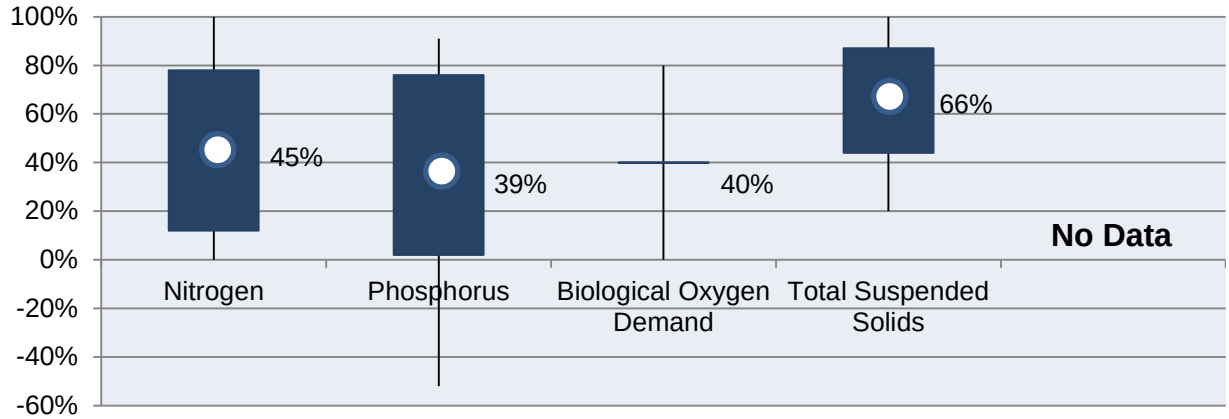
Who should use a forested riparian buffer?

The larger size required for a forested riparian buffer limits the possible land applications. Typically, they are applied near new developments with the buffer as an established preservation area. They are then maintained through easements or a community association. Buffers can also be installed in existing developed areas but may require an easement from landowners.

How effective is a forested riparian buffer at removing pollutants?

The data shown in the graph was obtained from 8 separate studies. A forested riparian buffer is able to remove approximately 45% of the nitrogen, 39% of the phosphorus, 40% of the BOD and 66% of the TSS from stormwater runoff.

Percent Removal of Pollutants



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GRASSED SWALE

Stormwater Best Management Practices

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What is a grassed swale?

A grassed swale is a stretch of land with a depression that is designed to remove pollutants from stormwater runoff. It is able to do this by slowing down the water before draining offsite. A grassed swale can be thought of as a broad, shallow vegetated drainage ditch. The main difference between a swale and a filter strip is that swales receive concentrated flows and filter strips receive evenly distributed flows.

Grassed swales can be used along roadsides and parking lots to collect and treat stormwater runoff

Source: EPA, 2001

Are there any secondary uses for a grassed swale?

Grassed swales are typically also used to transport stormwater runoff. A well designed grass swale should be able to handle a 2-year storm with little to no erosion. This same grassed swale should also be capable of handling a 10-year storm safely.

How is a grassed swale designed?

It is recommended that grassed swales be built on land with a 1-2 percent slope. However, it is acceptable to build a grassed swale on land with up to a 4 percent slope. Grassed swales typically have a trapezoidal or semi-circular cross-sectional area and the rate of pollutant removal is directly proportional to the cross-sectional area. The swale should be 2-8 ft. wide at the bottom and the length should be long enough to hold the water for 10 minutes. The length of the swale is calculated by multiplying the velocity (ft. / s.) by 600 s., the residence time of the water. Swales can be used to treat up to 5 acres of on-site drainage. The soil in the grassed swale area should also be permeable to allow for infiltration. Any water pooled after a storm event should be completely gone within 48 hours. Grassed swales work best in series with other best management practices to achieve the highest rate of pollution removal. For example, a grassed swale could drain into a dry detention basin for further treatment.

Are there other types of swales?

Yes, there are four variations on this type of system which include dry swale, wet swale, biofilter, and bioswale. A grassed swale can also be referred to as an open channel, infiltration swale, or vegetated swale.

How much does it cost to install and maintain a grassed swale?

A grassed swale requires regular maintenance like any grassy area or lawn. Litter that accumulates through the stormwater runoff must be frequently collected to maintain its effectiveness. One evaluation performed by the EPA in 2001 suggests that it would cost $0.50 per square ft. to install a grassed swale.

Are there any special considerations?

Grassed swales also act as a drainage ditch for many different types of projects. If a drainage ditch is already planned it is more appropriate to look at the cost of a grassed swale versus a concrete drainage ditch. Generally, it is much cheaper to construct a grassed swale than it is to construct a concrete drainage ditch.

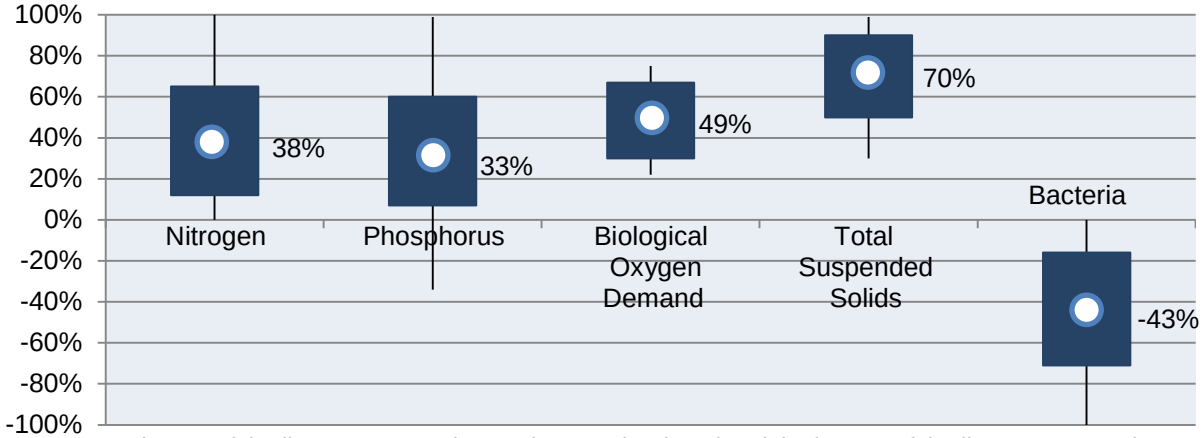
Who should use a grassed swale?

Grassed swales are ideal for residential areas and near roads and highways. They are well suited for these locations because they are a more environmentally friendly solution to the typical concrete drainage ditch. The linearity of the swale mirrors the road and swales are less hazardous than the steep and deep concrete drainage ditches.

How effective is a grassed swale at removing pollutants?

The data shown in the following table and graph were obtained from 42 separate studies. A grassed swale is able to remove approximately 38% of the nitrogen, 33% of the phosphorus, 49% of the BOD, 70% of the TSS, and -43% of the bacteria from stormwater runoff.

Percent Removal of Pollutants



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INFILTRATION BASIN

Stormwater Best Management Practices

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What is an infiltration basin?

An infiltration basin is a shallow reservoir that is intended to let stormwater permeate into the ground. By letting the stormwater soak into the soil, this system is able to filter out many of the large and small particles and dissolved pollutants. The biggest difference between an infiltration basin and a dry detention basin is that all water that enters an infiltration basin should permeate the ground.

Infiltration basins are designed to collect stormwater from impervious areas and provide pollutant removal benefits through detention and filtration

Source: EPA, 2001

Are there any secondary uses for an infiltration basin?

Yes, the water that flows into the infiltration basin can recharge the groundwater. Stream systems will also benefit from this because the groundwater flows into the streams.

How is an infiltration basin designed?

Infiltration basin sizes are typically 2%-3% of the site that is draining to them. Typically, an infiltration basin will be used in areas less than 10 acres. The soil surrounding the basin should be highly stable so that it does not clog the basin with sediment. The soil in the basin should be highly permeable; soils in infiltration basins are typically sandy, in order to prevent clogging or slow drainage. Most basins are designed so that they can be emptied within 3 or 4 days. Infiltration basins cannot handle very large inflows and therefore are typically used in conjunction with a flow separator to divert excess stormwater from the basin. Many times a drain is also installed so that if the basin becomes clogged, the basin can still be drained and maintenance can be performed.

Where is this type of system most effective?

Infiltration basins can be constructed most anywhere in the country. The biggest exception is areas that are near regions with highly contaminated runoff. The contaminated runoff is less likely to be filtered properly, and could leach into the groundwater. Also, infiltration basins typically require 2%-3% of the site draining to them, and would not be an appropriate system to place in an ultra-urban area.

How much does it cost to install and maintain an infiltration basin?

Costs are highly variable and are largely based upon the permeability of the soil. CED Engineering estimated in 2001 that it would cost approximately $2 per cubic ft. of storage. Maintenance is also variable. A large portion of the cost comes intermittently to unclog the system.

Are there any special considerations?

Infiltration basins work well in many conditions. When infiltration basins were first put into use they would frequently clog and leave standing water in the basin for many days. This kept the removal rates very low. If an infiltration basin is used as a BMP it should be rigorously maintained so that clogging does not occur. If the area has highly permeable soil it is less likely to clog.

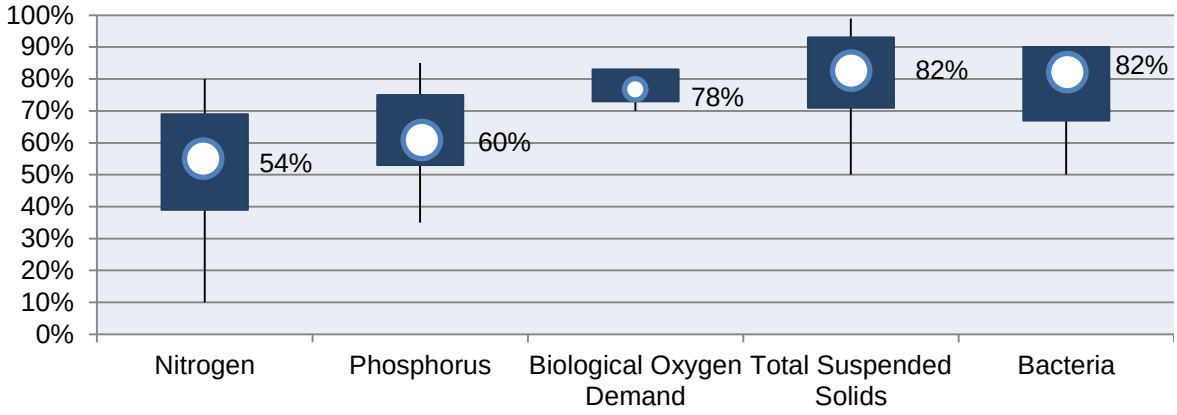
Who should use an infiltration basin?

Typically, infiltration basins have been used as regional facilities, serving for both water quantity and quality control. An infiltration basin's quality control is highly variable upon the type of soil in the area. This type of BMP is most appropriate for areas with sandy soil.

How effective is an infiltration basin at removing pollutants?

The data shown in the following table and graph were obtained from 23 separate studies. An infiltration basin is able to remove approximately 54% of the nitrogen, 60% of the phosphorus, 78% of the BOD, 82% of the TSS and 82% of the bacteria from stormwater runoff.

Percent Removal of Pollutants



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INFILTRATION TRENCH

Stormwater Best Management Practices

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What is an infiltration trench?

An infiltration trench is a channel with no outlet that is filled with rocks. The trench receives stormwater runoff which is held in the trench until it is absorbed into the soil. The soil filters the stormwater so that it may then recharge the groundwater.

Source: http://www.csc.temple.edu/t-vssi/bmpsurvey/delaware_countycc.htm

Are there any secondary uses for an infiltration basin?

Yes, the water that flows into the infiltration trench can recharge the groundwater. Stream systems will also benefit from this because the groundwater flows into the streams as base flow.

Are there other names for this type of system?

Yes, infiltration trenches are also known as infiltration galleys.

How is an infiltration trench created?

Infiltration trenches are typically used for smaller sites, less than 5 acres, which have high amounts of impervious cover. They are usually installed in areas with sandy soils. The trench itself should be sited on a flat area. The land that surrounds the trench can be as steep as 15 percent. The soil in the trench should be highly permeable, 0.5-3 in. / hr., to reduce the likelihood of clogging. The stormwater runoff should be pretreated by another BMP before entering the trench. Most trenches are designed to be emptied within 24 hours. An observation well should be installed so that the rate of infiltration can be measured. Many times a drain is also installed so that if the trench becomes clogged, it can be drained and maintained.

Where is this type of system most effective?

Infiltration trenches can be constructed most anywhere in the country. The biggest exception is with highly contaminated runoff. The contaminated runoff is less likely to be filtered properly and could leach into the groundwater. There are also some issues with infiltration trenches in colder climates because of permafrost, snowmelt, and road salt.

How much does it cost to install and maintain an infiltration trench?

Costs are highly variable and are largely based upon the permeability of the soil. The California Stormwater Quality Association estimated that it would cost $5 per cubic ft. of treated volume. Maintenance is also variable and a large portion comes intermittently when the trench becomes clogged.

Are there any special considerations?

When the infiltration trench was first put into use, clogging was an issue. Since the standing water is below grade, mosquitoes and pests are not an issue. Maintenance needs have been determined to reduce the occurrence of clogging. If an infiltration trench is used as a BMP it should be routinely maintained so that clogging is limited.

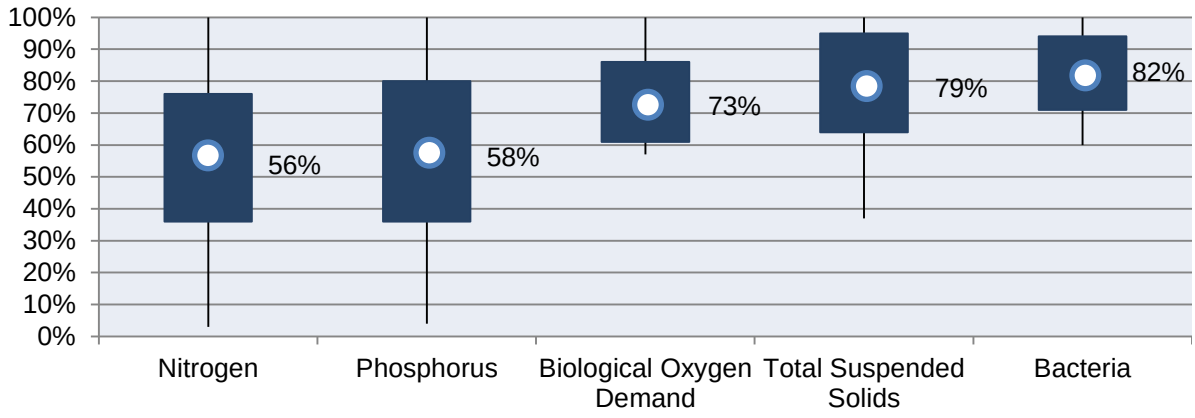
Who should use an infiltration trench?

Infiltration trenches are generally used on sites less than 5 acres that have a high impervious cover. Native soil conditions will determine design capacity for all locations.

How effective is an infiltration trench at removing pollutants?

The data shown in the following table and graph were obtained from 18 separate studies. Infiltration trenches are able to remove approximately 56% of the nitrogen, 58% of the phosphorus, 73% of the BOD, 79% of the TSS and 82% of the bacteria from stormwater runoff.

Percent Removal of Pollutants



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PERMEABLE PAVEMENT

Stormwater Best Management Practices

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What is permeable pavement?

Permeable pavement is specially designed pavement with extra pores that allows water to pass through it without compromising the integrity of the material. The permeability of the pavement controls runoff volumes and rates.

Figure 1. Pervious concrete allows water to flow through it. *Photo courtesy of the National Ready Mix Concrete Association*

Are there any secondary uses for permeable pavement?

Permeable pavement was designed to be used in lieu of typical asphalt or concrete. It can replace most traditional impervious pavement.

How is permeable pavement designed?

Most systems use reduced amounts of sand or fine particles so that more gaps are created in the structure of the pavement. The additional gaps allow water to drain through it. The typical amount of void space in permeable pavement is between 15 and 35 percent, compared to 3-5 percent void space in traditional concrete. Many times pretreatment systems, such as swales and filter strips, are used in conjunction with pervious pavement to prevent clogging. The soil beneath the pavement should be stable and permeable so that the water may be filtered by the soil. When a pavement is poured above a clay base, a drain located underneath the pavement is used to drain the water properly. Most soils around the Houston/Galveston area are clayey. Therefore it is highly recommended.

Are there other names for this type of system?

Yes, there are many different types of permeable pavement including pervious concrete, porous concrete, gap-graded concrete, enhanced porosity concrete, porous pavement, and porous asphalt. There are other materials and designs that are similar to permeable pavement such as permeable interlocking concrete pavement, concrete grid pavement, and modular porous paver system.

How much does it cost to install and maintain permeable pavement?

This technology is recent and is still going through adjustments as more providers enter the market. As of 2005 the National Cooperative Highway Research Program (NCHRP) estimated that the cost of the pervious concrete material would be $2-$7 per square ft. The pavement needs the same maintenance as a typical roadway. It should also be unclogged by a vacuum street cleaner when necessary.

Are there any special considerations?

The use of permeable pavement can help offset the amount of additional land and expenses that would be incurred by having to install the typical collection, conveyance, and detention stormwater components. Permeable pavement requires special installation although it is becoming a more frequent practice.

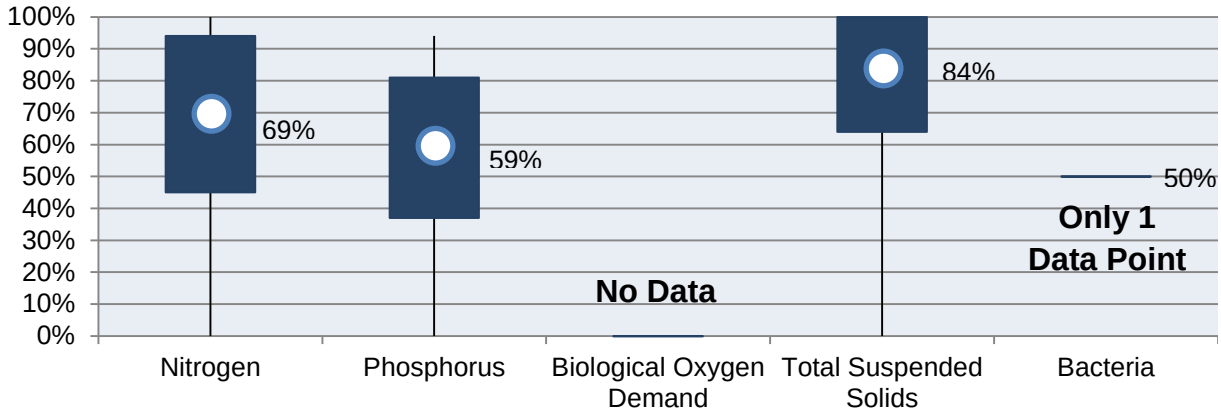
Who should use permeable pavement?

Permeable pavement is typically used as alternatives for sidewalks, driveways, parking lots, or lesser used streets. Permeable pavement can be either poured or built with pavers making it an accessible option for replacing material on any type of land.

How effective is permeable pavement at removing pollutants?

The data shown in the following table and graph were obtained from 22 separate studies. Permeable pavement is able to remove approximately 69% of the nitrogen, 56% of the phosphorus and 84% of the TSS from stormwater runoff.

Percent Removal of Pollutants



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BIORETENTION AREAS

Stormwater Best Management Practices

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What is a bioretention area?

Bioretention areas are planted shallow depressions that collect and treat stormwater runoff through landscaping. They are typically found in suburban environments and small areas of land. The bioretention filters runoff then diverts it into the storm drain system. Bioretention areas are similar to infiltration basins but the emphasis is placed on vegetation in bioretention areas.

Source: EPA, 2001

Are there other names for this type of system?

Yes. A commonly used term for a bioretention area is rain garden.

Can I turn my yard into a bioretention area?

Yes. Most landscaped yards can easily be converted into a bioretention area by selecting the appropriate site and plants.

How is a bioretention area designed?

A bioretention area is typically created in suburban areas with little space for stormwater best management practices. A typical bioretention area is approximately 5%-10% of the size of land that drains to the bioretention area. The maximum amount of land a bioretention area can accommodate is 5 acres, including the bioretention area. Bioretention areas can be created in any type of soil. The slope of the surrounding land should be toward the bioretention area. The filtered water is typically drained to the stormwater system. Rain gardens at commercial sites should use a perforated under drain to move the filtered runoff to the stormwater system. Residential rain gardens do not typically need an under drain system.

What kinds of plants should I put in my bioretention area?

It is preferable to plant native vegetation that also provides habitat value and attracts beneficial insects. The plants selected should be able to withstand both wet and dry conditions. Trees can also be used in bioretention areas. Plants preferring wet soils should be planted in the middle and plants preferring dryer soils along the edge.

How much does it cost to install and maintain bioretention areas?

The EPA uses the following equation to estimate the construction, design, and permitting cost of a bioretention area, approximately as $C = 7.30V$,
Where C is the total cost and V is the volume of water treated by the bioretention area in cubic ft. In 2011, the Texas AgriLIFE Extension Service estimated that it would cost $6 per sq. ft. to install a bioretention area. The maintenance of the bioretention area is similar to the cost of maintaining a typical yard.

Are there any special considerations?

Bioretention areas can be used near stormwater hot spots, areas where highly contaminated runoff may occur. There is one design constraint that should be followed before applying it to this type of area: an impermeable liner should be installed underneath the bed. The liner should be installed so that if any of the runoff bypasses the drain it will not cause any contamination problems to the groundwater.

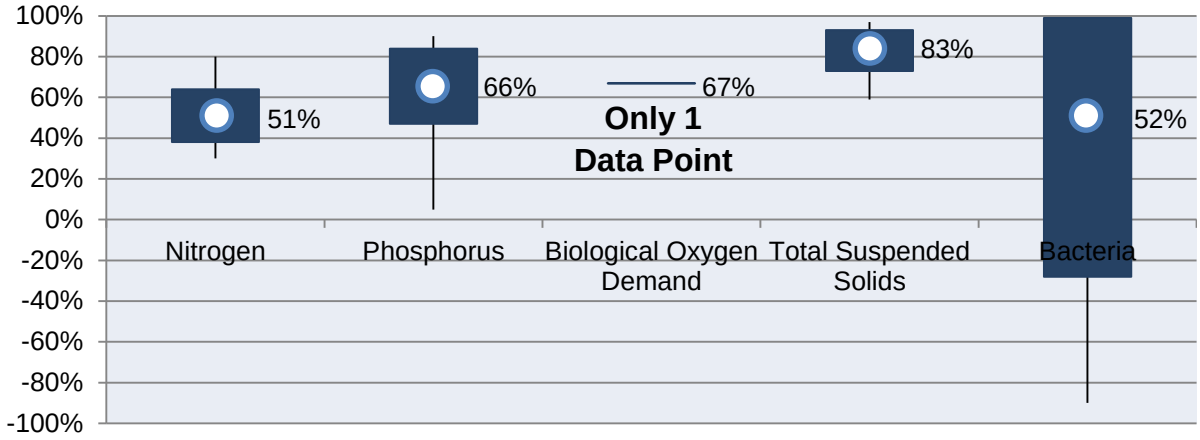
Who should use a bioretention area?

Bioretention areas are typically used to treat parking lot runoff, residential or roof runoff. Bioretention areas are also well suited for highly urbanized areas.

How effective is a bioretention area at removing pollutants?

The data shown in the following table and graph were obtained from 25 separate studies. A bioretention area is able to remove approximately 51% of the nitrogen, 66% of the phosphorus, 83% of the TSS and 52% of the bacteria from storm water runoff.

Percent Removal of Pollutants



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WATER QUALITY INLETS

Stormwater Best Management Practices

14

What is a water quality inlet?

Water quality inlets are a group of methods that capture or separate sediment, debris, and pollutants from stormwater runoff as it enters a catchment basin. It typically acts as a pretreatment for other stormwater best management practices. Water quality inlets are typically used in areas with little available space as they normally require only an insert into an existing storm drain.

A worker inserts a catch basin insert for oil and grease, trash, debris, and sediment removal from stormwater as it enters the storm drainage system (Source: Ab Tech Industries, 2001)

Are there other names for this type of system?

Yes. Water quality inlets are also known as catch basin inserts, storm drain inlets or curb inlets. There are many specific types of each of these such as an oil/grit separator which removes oil from incoming runoff.

How does a water quality inlet work?

A water quality inlet can operate in a variety of ways. Most use physical processes to remove larger particles and trash. A grate or curb inlet only allows materials smaller than the inlet area into the basin. A series of media filters can be used to remove smaller particles. The efficiency of the water quality inlet depends heavily on the design of the inlet and on regular maintenance.

How big does the water quality inlet need to be?

The catch basin is the area where the stormwater runoff eventually enters before passing through the water quality inlet. The EPA suggests the following estimates to determine the catch basin size. First, the diameter of the catch basin should be 4 times the size of the outlet pipe diameter. Secondly, the depth should be at least 4 times the size of the outlet pipe diameter. Lastly, the top of the outlet pipe should be 1.5 times the size of the outlet pipe diameter, from the bottom of the inlet to the catch basin. Most catch basins are sized with a margin of safety so if an extremely large rainfall event occurs the catchment basin will still be able to handle most of the incoming rain.

Authors: Derek Morrison and Steven Mikulencak

How much does it cost to install and maintain a water quality inlet?

Water quality inlets are highly variable in price. They are priced based upon how efficient they are and the size of particles they can remove. A catch basin insert costs approximately $2,000-$3,000 per insert (Study performed by Cambridge University in 2012). Another cost consideration is the cost to remove the debris from the basin and inlets. Cleaning the debris from the inlets will require routine maintenance.

Are there any special considerations?

Water quality inlets and catch basins have three major limitations. First, even if they are designed and maintained properly they cannot remove pollutants as efficiently as other structural stormwater best management practices such as wet ponds or sand filters. Secondly, they require routine maintenance. Lastly, water quality inlets and catch basins cannot successfully remove many of the smaller or soluble particles.

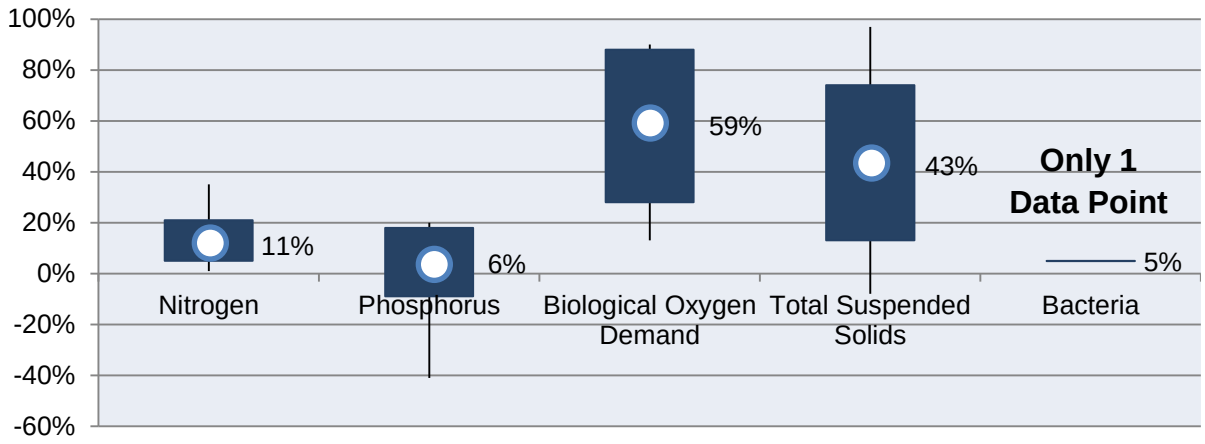
Who should use water quality inlets?

Water quality inlets are typically placed before or in municipal storm sewer lines. Water quality inlets are also placed in storm sewer lines that are exiting commercial buildings. Water quality inlets are generally not used by individual residents of a community.

How effective is a water quality inlet at removing pollutants?

The data shown in the following table and graph were obtained from 18 separate studies. Water quality inlets remove approximately 11% of the nitrogen, 6% of the phosphorus, 59% of the BOD and 43% of the TSS from stormwater runoff.

Percent Removal of Pollutants



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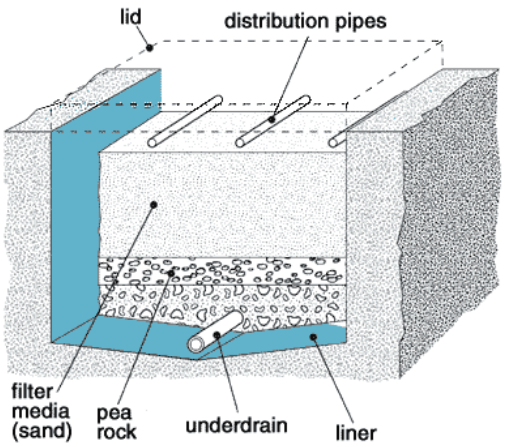
SAND AND ORGANIC FILTERS

Stormwater Best Management Practices

15

What is a sand and organic filter?

Sand and organic filters typically consist of two chambers. The first chamber is a settling chamber and the second chamber is filled with sand or other filtering organic material. The bottom of the filter contains a drain so that the filtered water can be moved away from the filter. Gravel is used to hold both the drain and sand in place. Sand and organic filters may be used as a stand-alone practice or as a pretreatment for an infiltration practice.



Source: http://www.extension.umn.edu/distribution/naturalresources/DD7672.html

Can sand and organic filters negatively affect groundwater?

No. However, it is advised that there should be at least 2 ft. of separation between the bottom of the filter and the high point of the groundwater to prevent structural damage to the filter.

How does a sand and organic filter work?

The first chamber, not filled with sand, allows large particles to settle out of the water on the top of the sand layer where they are caught. A small perforated pipe then removes the water from the first chamber and deposits it into the second chamber. The second chamber filters out the smaller particles by capturing the smaller particles in the spaces between the grains of sand. Sand and organic filters should not be used on large sites. They are most efficient at treating runoff from sites less than 10 acres for surface sand filters and less than 2 acres for perimeter or underground sand filters. There should be some slope from the land supplying the runoff because the filter requires an elevation drop between the land and the filter. It is suggested that a minimum elevation drop of 5 ft. for underground and surface sand filters while the perimeter sand filter requires a minimum of a 2 ft. elevation drop.

Are there other names for this type of system?

Yes. Sand and organic filters are also known as organic media filters, and multi-chamber treatment chains. There are variations of the basic sand and organic filters such as underground sand filters, surface sand filters, and perimeter sand filters. There are different rules, regulations, design standards, and placement concerns for each of the variations.

Authors: Derek Morrison and Steven Mikulencak

How much does it cost to install and maintain a sand and organic filter?

The cost varies widely and depends upon the type of filter and the variation of the filter. The EPA estimated in 2006 that it would cost approximately $5 per cubic ft. of stormwater treated. The maintenance costs of the filters come from monthly cleaning of debris and the prevention of clogging. Clogging occurs when large particles are not effectively removed in the first chamber.

Are there any special considerations?

A sand and organic filter can be used to treat stormwater hotspots. Stormwater hotspots refer to any type of land that generates highly contaminated runoff such as commercial nurseries, storage areas, marinas, and vehicle cleaning facilities. Sand and organic filters are well equipped to treat the hotspots because they have no interaction with the groundwater.

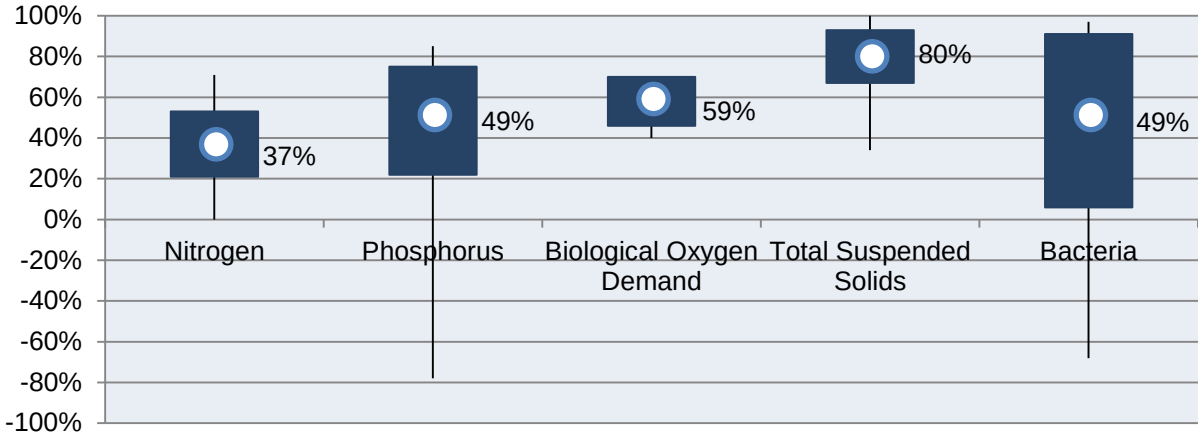
Who should use a sand and organic filter?

Underground and perimeter sand and organic filters are excellent choices for urban areas because of the minimal area needed. These types of filters work best for smaller drainage areas.

How effective is a sand and organic filter at removing pollutants?

The data shown in the following table and graph were obtained from 43 separate studies. A sand and organic filter is able to remove approximately 37% of the nitrogen, 49% of the phosphorus, 59% of the BOD, 80% of the TSS and 49% of the bacteria from stormwater runoff.

Percent Removal of Pollutants



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VEGETATED FILTER STRIPS

Stormwater Best Management Practices

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What is a vegetated filter strip?

Vegetated filter strips are vegetated areas that slow and treat sheet flow from stormwater runoff. Typically they are rectangular but can be constructed in almost any shape. Vegetated filter strips are typically installed along the sides of roads and highways, near roof downspouts, and around parking lots. They require a large amount of space and are not normally seen in ultra-urban areas. Vegetated filter strips were originally an agricultural best management practice but have slowly caught on in urban areas. The main difference between a swale and a filter strip is that filter strips receive evenly distributed flows but do not direct water off site, whereas swales receive concentrated flows and direct these flows.

Source: http://www.semcog.org/data/lid.report.cfm?lid=170

Are there other names for this type of system?

Yes. Vegetated filter strips are also known as grassed filter strips, filter strips, and grassed filters.

How does a vegetated filter strip work?

Vegetated filter strips work by slowing the stormwater runoff. Slowing the runoff velocity allows larger particles to settle out of the water and into the filter strip. The vegetation is able to filter out many of the smaller particles. Slowing the water allows some of the water to infiltrate into the underlying soils which filters out more pollutants. Vegetated filter strips are used to treat small drainage areas, typically less than 1 acre.

How is a vegetated filter strip designed?

A small pea gravel trench runs along the top edge of the strip so flows can spread out along the length of the strip as well as for pretreatment. The bottom of the strip should contain a small area for ponding. Most filter strips are at least 25 ft. long and are built on land with a slope between 2 and 6 percent. The plant material used to fill the filter strip should be able to withstand both dry and wet conditions. Highly clayey soils may limit infiltration performance.

How much does it cost to install and maintain a vegetated filter strip?

The average cost of a vegetated filter strip in 2001 was around $13,000-$30,000 per acre. Filter strips have similar maintenance requirements as other vegetative practices, such as grassed swales. The biggest maintenance concern is making sure that the water flow does not get concentrated in channels allowing it to bypass the filter.

Are there any special considerations?

In determining if a vegetated filter strip is appropriate, remember that the vegetation is important to the success of the water filtration. This means that the vegetation needs to be properly maintained and watered during periods of drought or in arid regions of the country. Also, holding too much water may cause issues and breed pests.

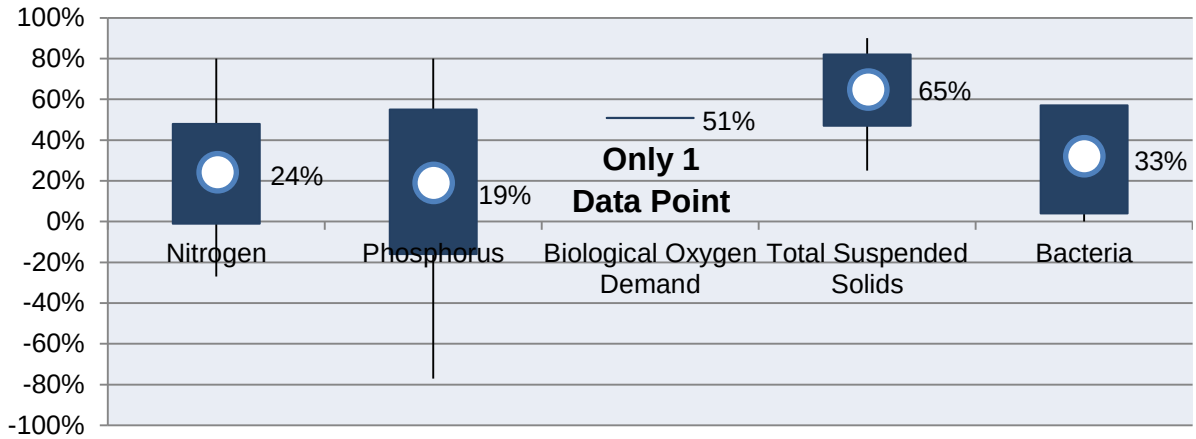
Who should use a vegetated filter strip?

Vegetated filter strips are best suited for treating runoff from roads and highways, roof downspouts, very small parking lots, and pervious surfaces. Vegetated filter strips are also occasionally used as the outer zone of a forested riparian buffer. They can also be used as pretreatment for other structural BMPs.

How effective is a vegetated filter strip at removing pollutants?

The data shown in the following table and graph were obtained from 19 separate studies. Vegetated filter strips are able to remove approximately 24% of the nitrogen, 19% of the phosphorus, 65% of the TSS and 33% of the bacteria from stormwater runoff.

Percent Removal of Pollutants



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DRY DETENTION BASIN

Stormwater Best Management Practices

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What is a dry detention basin?

A dry detention basin is large, typically vegetated basin that only holds water for a short period after it rains. The basin has outlets designed to detain stormwater runoff for 24 hours. They are called dry detention basins because they do not hold water permanently. The biggest difference between an infiltration basin and a dry detention basin is that a majority of the water that enters a dry detention basin does not permeate into the ground.

Source: EPA, 2001

Are there other names for this type of system?

Yes. Dry detention basins are also known as dry ponds, extended detention basins, detention basins, extended detention ponds, and detention tanks.

Are there any secondary uses for this system?

Yes. Dry detention basins can also be used for flood control by providing flood detention storage.

How does a dry detention basin work?

Dry detention basins work by allowing larger particles and sediment to settle out of the water column. Once the particles have settled to the bottom of the pond they get caught in the soil. Dry detention basins should not be used as a single pollution solution because they do not have a high efficiency. Dry detention basins are primarily used for volume flood control.

How is a dry detention basin designed?

Dry detention basins are typically quite large and require a large amount of land to construct. A typical dry detention basin is generally used on sites larger than 10 acres, although smaller sites work. The slope of the adjacent land can be high. The slope immediately around the pond should be lower. The EPA recommends that the pond be built using a length-to-width ration of at least 1.5:1. Almost all soil types can work in a dry detention basin with some minor adjustments. Dry detention basins that come in contact with highly contaminated runoff should be lined with an impermeable liner so that the groundwater does not become contaminated. Also, the basin should not be so deep that it intersects the groundwater table. This would cause a permanent pool of water in the bottom which could be a potential breeding ground for mosquitoes.

How much does it cost to install and maintain a dry detention basin?

A fairly common equation used to price a dry detention basin is:

$$C = 12.4 * V^{0.76}$$

Where C is the construction cost of the dry detention basin and V is the volume needed to control a 10-year storm in cubic ft. This equation was created in 1997 and should be adjusted for inflation to express a more accurate estimate.

Are there any special considerations?

A dry detention basin should never intersect the groundwater table. In Texas, specifically near the coast, the groundwater table is not very deep. This means that the detention basin cannot be dug deeper in order to have the required amount of volume in the dry detention basin. The length or width of the detention basin must be changed which would require a larger amount of land.

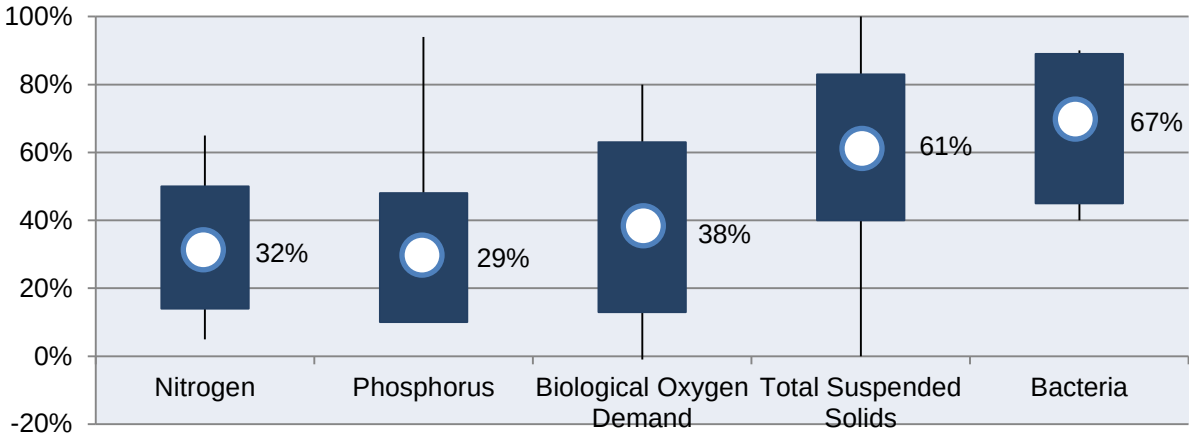
Who should use a dry detention basin?

Dry detention basins are one of the most widely used BMPs and can be applied to all regions of the country. Many dry detention basins are used for flood control as well as water quality improvement. Dry detention basins are typically used for sites larger than 10 acres.

How effective is a dry detention basin at removing pollutants?

The data shown in the following table and graph were obtained from 32 separate studies. A dry detention basin is able to remove approximately 32% of the nitrogen, 29% of the phosphorus, 38% of the BOD, 61% of the TSS and 67% of the bacteria from stormwater runoff.

Percent Removal of Pollutants



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STORMWATER WETLAND

Stormwater Best Management Practices

18

What is a stormwater wetland?

A stormwater wetland is a constructed pond that integrates natural wetland vegetation. Stormwater wetlands actively filter stormwater runoff by allowing the particles to settle in the standing water and by filtering the smaller particles through infiltration. Not only are stormwater wetlands efficient at removing pollutants from runoff, they also provide an aesthetic value and significant habitat for resident wildlife. The surface area of a stormwater wetland is typically 1% of the area draining into it.

A group of people help to plant new wetland vegetation

Source: EPA, 2001

Are there other names for this type of system?

Yes. Recent human disturbances have disrupted many of the natural wetlands. Therefore, many wetlands are now being artificially created, these are known as artificial or constructed wetlands.

Do I need a permit to replant or construct an artificial wetland?

It depends. If you are performing any restoration on a wetland you must get a permit from the U.S. Army Corps of Engineers. This is specified under the Clean Water Act, Section 404. It states that you need a permit if the wetland has a significant connection to a navigable waterway. Traditionally, the U.S. Army Corps of Engineers is not involved with artificial wetland permitting but it is highly advised to contact them to determine if you need a permit to construct the wetland.

What type of plants should I put in a wetland?

The proposed development site's history should be researched. This includes previous vegetation, typical conditions, and hydrologic characteristics. These factors will heavily influence which plants should be selected. It is important to keep the plant species diverse to keep one particular plant from dominating the wetland. It is also important to plant riparian vegetation along the banks of the wetland. Vegetation will help keep the banks stable and reduce water temperatures. The efficiency of using a stormwater wetland to remove pollutants is highly variable and depends on the types of plants used. A local Extension representative, such as the Texas Coastal Watershed Program, is a good source of technical information.

Texas Coastal Watershed Program
Texas A&M University System
Authors: Derek Morrison and Steven Mikulencak

For sources and citations on this Fact Sheet, please visit:
www.urban-nature.org

How much does it cost to install and maintain a stormwater wetland?

The cost to install an artificial wetland is highly variable and depends on the amount of restoration or construction. The EPA estimates that constructing a wetland is approximately 25% more expensive than a stormwater pond of an equivalent volume. The EPA also estimated that the annual maintenance of the wetland is about 3%-5% of the construction cost.

Are there any special considerations?

Regular maintenance is important, and steps should be taken to minimize erosion in areas surrounding the wetland. Sediment will accumulate and change the flow pattern in the wetland. The biggest maintenance consideration is invasion of non-native plant life. Invasive plant species should be removed wherever possible. Managing cattails should also be a maintenance priority because they are an optimal space for mosquito breeding. Cattails should be avoided and make up <10% of the total vegetation.

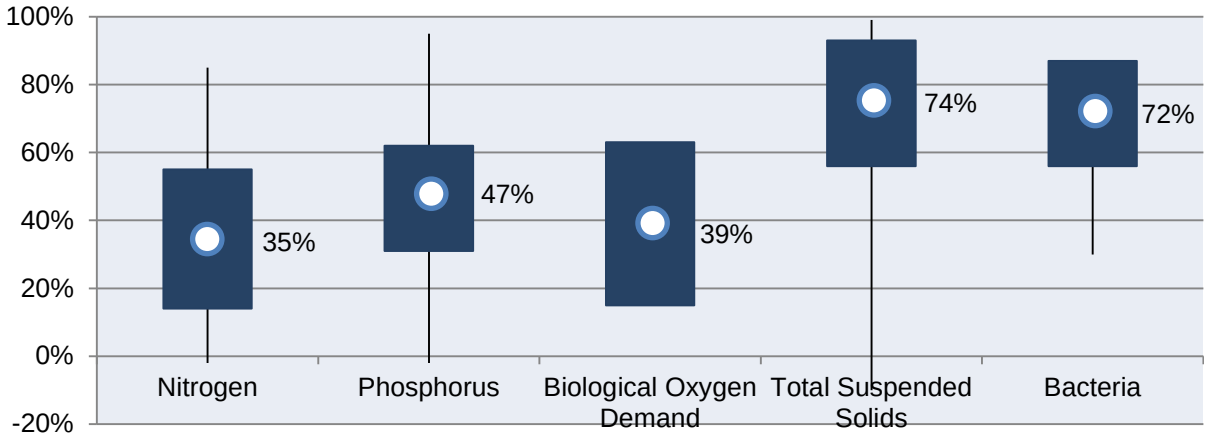
Who should use a stormwater wetland?

Stormwater wetlands are typically at least 1% of the drainage area and should have a length-to-width ratio of 1.5:1. Stormwater wetlands should not negatively impact natural wetlands or forests. Most stormwater wetlands are used for treatment in suburban or rural areas.

How effective is a stormwater wetland at removing pollutants?

The data shown in the following table and graph were obtained from 31 separate studies. A stormwater wetland is able to remove approximately 35% of the nitrogen, 47% of the phosphorus, 39% of the BOD, 74% of the TSS and 72% of the bacteria from stormwater runoff.

Percent Removal of Pollutants



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WET DETENTION POND

Stormwater Best Management Practices

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What is a wet detention pond?

A wet detention pond is a constructed basin with a permanent pool of water throughout the year. Wet detention ponds are a commonly seen stormwater best management practice. They can be applied to almost any situation and can be installed throughout the country. The primary limitations of a wet detention pond are the size of the pond and the use in more arid regions of the country. Wet detention ponds allow larger particles to settle out of the water. Smaller particles are removed through infiltration of the vegetation on the sides of the basin. The main difference between a wet detention pond and a stormwater wetland is that a wet detention pond does not rely on vegetation for filtration.

Source: EPA, 2001

Are there other names for this type of system?

Yes. Wet detention ponds are also called wet ponds, stormwater ponds, wet retention ponds, wet extended detention ponds, settling basins, retention basins, or sediment basins.

How is a wet detention pond designed?

Wet detention ponds need a large enough drainage area so that they can maintain the permanent pool. In more humid regions, like the Texas Gulf Coast, it typically requires about 25 acres. The drainage area size should be larger in areas where it rains less. The slope of the adjacent land can be up to 15 percent but the land near the pond should be relatively flat with a slight slope toward the outlet of the pond. This will ensure that the water continuously flows toward the outlet. Wet detention ponds can be used in almost any soil type. A wet detention pond, unlike a dry detention pond, is able to cross the boundary of the groundwater. However, some studies have shown that when groundwater contributes significant amounts of water to the pond, it may decrease the pollutant removal efficiency. Water should pass through a small basin before reaching the detention pond so that the largest particles can settle out of the water, decreasing sedimentation in the main pond and reducing the amount of maintenance needed. The EPA recommends that the pond be built using a length-to-width ratio of at least 1.5:1.The EPA also recommends using underwater berms so water travels a further distance, thus allowing the particles to have a longer time to settle. A vegetated buffer should be placed along the edges of the pond to provide shade.

How much does it cost to install and maintain a wet detention pond?

One commonly used equation by the EPA to estimate the construction cost of a wet detention pond was created in 1997 but is adjusted for inflation:

$$C = 24.5 * V^{0.705}$$

Where C is the construction cost and V is the volume of the pond that is capable of carrying a 10-year storm. Annual maintenance costs are about 3% to 5% of the construction cost.

Are there any special considerations?

Some companies are beginning to reuse the pond water for non-potable uses such as irrigation. In this case, then the daily amount of water intake and output should be calculated for the pond to ensure that a constant pool of water is maintained. One study performed at a Florida golf course concluded that reusing the pond water would cost about 1/7th the typical irrigation cost.

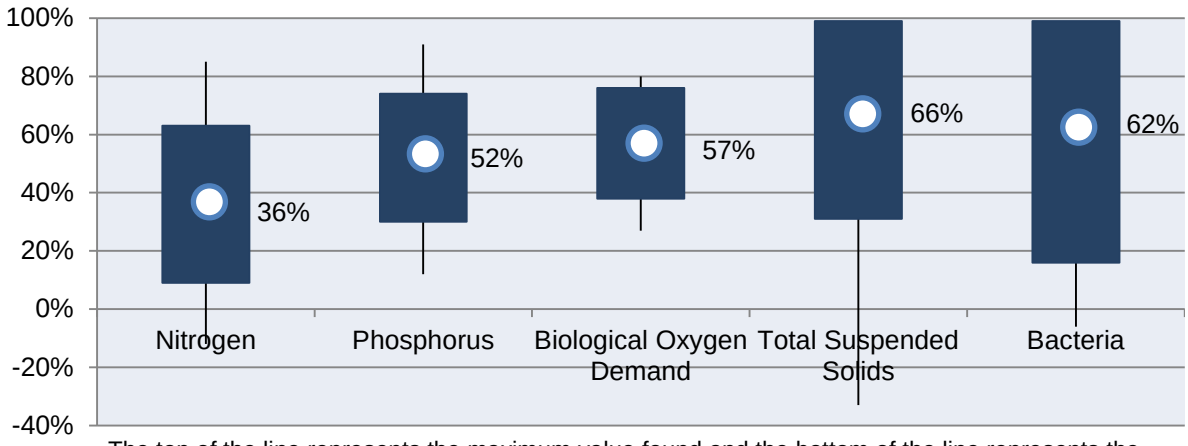
Who should use a wet detention pond?

Typically, a wet detention pond is used in a neighborhood, community, or recreational parks. If a wet detention pond is landscaped well it adds to the aesthetic value of these places and can make the wet detention pond an asset to that community. The water in the pond may also be used for other needs such as irrigation.

How effective is a wet detention pond at removing pollutants?

The data shown in the following table and graph were obtained from 31 separate studies. A wet detention pond is able to remove approximately 36% of the nitrogen, 52% of the phosphorus, 57% of the BOD, 66% of the TSS and 62% of the bacteria in stormwater runoff.

Percent Removal of Pollutants



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HOW TO PICK THE RIGHT BEST MANAGEMENT PRACTICE 20

Stormwater Best Management Practices

What is a Best Management Practice?

Best Management Practices (BMPs) are practices that help treat, store, and infiltrate stormwater runoff from impermeable areas. If BMPs were not installed, the contaminated stormwater runoff would negatively impact the local water bodies downstream. The technology used in BMPs varies widely. Some rely on complicated chemical processes while others rely on simple, physical processes. They range in size from a few square feet to many cubic yards. Some BMPs are not based on structure or technology at all. For example, if you can educate the local community to stop performing adverse behavior, that action will help reduce the amount of pollutants in the water with no installation of a physical structure. BMPs, if properly installed and maintained can last for many years and help lessen water contamination.

Is it required that I install a Best Management Practice?

Yes, but only if it is a new development or redevelopment that disturbs more than one acre and happens in either a Phase I or Phase II MS4 (Municipal Separate Storm Sewer Systems). Everyone is encouraged to install a BMP on their property but it is only required by the people meeting the criteria mentioned above.

Why do I need a Best Management Practice?

Water that runs through impermeable areas is highly susceptible to becoming contaminated with pollutants that it picks up on its way out. That runoff eventually enters either a natural body of water or a storm drain. Either way, the contaminated runoff water then negatively affects the water it mixes with. This can cause serious impairments to water that are used as recreation sites or as a drinking water source. BMPs help reduce the amount of contaminants that make it into these bodies of water.

How do I know which BMP is right for me?

There are many questions that must be addressed before a final decision can be made. The first questions that should be asked are:

1. How big is your property?
2. How much space and what shape of the space is available for a BMP?
3. How effective should the BMP be?
4. Are there any BMPs already installed on the property?

More questions may need to be asked before making a final decision. If there are multiple practices that fit into these categories then a secondary tool that can be used is called a score sheet.

Authors: Derek Morrison and Steven Mikulencak

What is a score sheet?

A score sheet is a method of determining which BMP would best fit your needs. Make a table that has the BMPs that match what you are looking for in each column. Each row has various concerns that should be taken into consideration such as, pollutant reduction (one column for each pollutant), cost, secondary uses, public acceptance, and maintenance costs. Any other special considerations that you would like to consider should also be entered. Each cell would then be numbered on a scale of 1-5, based on the appropriate measures, with 1 being the worst and 5 being the best. During this process you should make the assumption that each practice will be installed and maintained properly. After each number has been selected, take the average number of each column. The BMP with the highest average would be the most appropriate selection for your land. Make sure to write notes on the method used to select a BMP.

Can I use multiple BMPs in a series?

Yes. If you choose to use multiple BMPs in a series, the rate of flow will decrease and the amount of contaminants will significantly decrease. If you do choose to use multiple BMPs in a series you cannot add the removal efficiencies together to determine the final removal efficiency. You must perform the removal efficiencies separately. This is because the water flows through the first BMP and some percentage of contaminated water still remains. The second removal efficiency only alters the remaining contaminant concentration.

Is there someone who can help me select the appropriate BMPs?

Any local Extension office should be able to answer any questions or help you select BMPs that would best suit your needs should you run into any conflicts.

Management Practice	Bioretention Area	Riparian Buffer	Wetland
Nitrogen Removal*	3	3	2
Phosphorus Removal*	4	2	3
BOD Removal*	4	3	2
TSS Removal*	5	4	4
Bacteria Removal*	3	No Data	4
Cost†	1	5	3
Secondary Uses†	3	5	3
Public Acceptance†	5	5	3
Maintenance†	3	3	5
Average Score	***3.44***	***3.75***	***3.22***

*Based on a numbering system of 0%-19% = 1, 20%-39% = 2, 40%-59% = 3, 60%-79% = 4, 80%-100% = 5.
† Chosen when compared to the other selected BMPs.

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