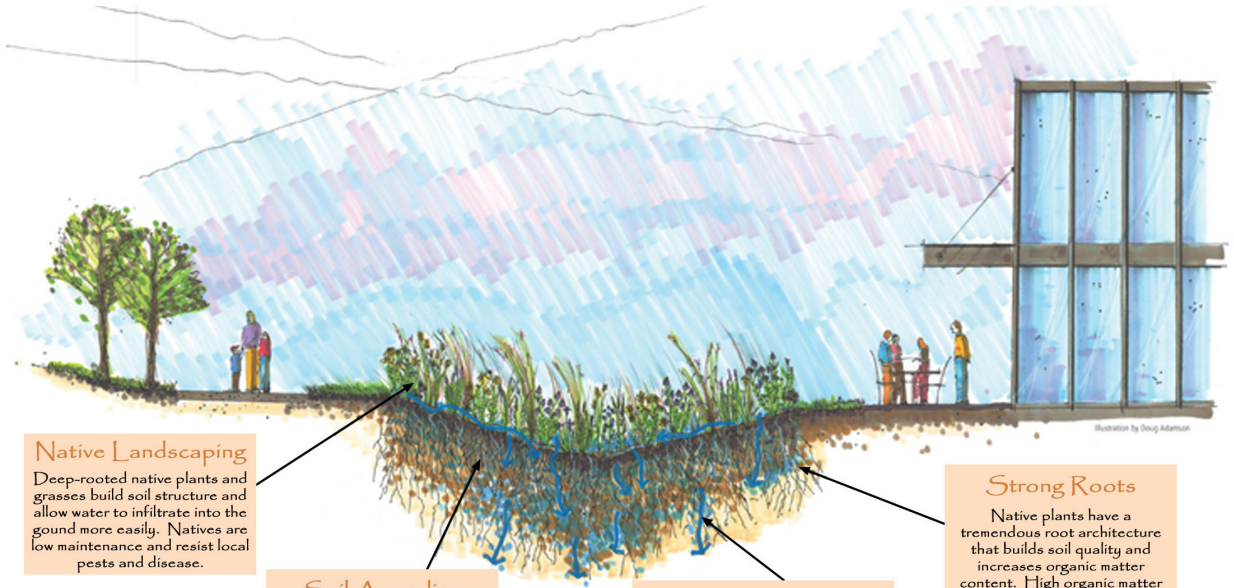
Vegetated Swale



Native Landscaping

Deep-rooted native plants and grasses build soil structure and allow water to infiltrate into the gound more easily. Natives are low maintenance and resist local pests and disease.

Soil Amending

Along with native plantings, soils amended with compost may be needed to facilitate infiltration.

Infiltration

Infiltrated water from bioswales helps recharge groundwater, which supplies rivers and streams with a slow, purified seep rather than surges of polluted surface runoff.

Strong Roots

Native plants have a tremendous root architecture that builds soil quality and increases organic matter content. High organic matter content helps soil hold water like a sponge, making it available for nourishing plants.

Original illustration Doug Adamson; modified by Cahill Associates

Vegetated Swales are broad shallow channels topped with vegetation, also known as "bioswales." Swales are designed to slow runoff, promote infiltration, and filter out pollutants and sediments. Vegetated Swales are a "green" alternative to conventional piping and are often called "Green Infrastructure" because they can take the place of a curb and gutter conveyance system.

Swales are planted in a layer of 24 inches (min.) of permeable soil with a high level of organic material to enhance pollutant removal. Swales constructed with an Infiltration Trench should contain an underlying 12 to 24 inch aggregate layer wrapped in a non-woven geotextile fabric. Adding an Infiltration Trench BMP under the Vegetated Swale BMP will significantly reduce the volume and rate of stormwater runoff.

Image: Montana NRCS USDA

An important element of a Vegetated Swale BMP is the ease at which it can be integrated into the landscape setting of a residential property. Often, this BMP can enhance the aesthetic value especially if appropriate native vegetation are utilized. Swales may also discreetly blend in with existing landscaping features - you may not even realize that this is a functional component of the stormwater management system. One important design point is to avoid excessive slope which can produce excessive stormwater flows that can be erosive and damaging.

Vegetated Swales can incorporate "check dams" which are small dams made of rock that slow runoff, allowing water to pool and infiltrate through the vegetation.

A Vegetated Swale typically contains the following components:

- Swale **Soil** shall be permeable with a higher percent organic content.
- Swale **Sand** (optional component) shall be a fine aggregate concrete sand (0.02 in to 0.04 in).
- **Check dams** if used, should be constructed of natural wood between 6" – 12" in diameter and notched as necessary. The following species are acceptable: Black Locust, Red Mulberry, Cedars, Catalpa, White Oak, Chestnut Oak, Black Walnut. The following species are not acceptable, as they can rot over time: Ash, Beech, Birch, Elm, Hackberry, hemlock, Hickories, Maples, Red and Black Oak, Pines, Poplar, Spruce, Sweetgum, and Willow.
    - An earthen check dam can be constructed of sand, gravel, and sandy loam to encourage grass cover (Sand: fine aggregate concrete sand 0.02" - 0.04" and Gravel: AASHTO M-43 0.5" - 1.0"). A stone check dam shall be constructed of R-4 rip rap, or equivalent.
- Native **plant** species
- If an **infiltration trench** is proposed, see the Infiltration Trench discussion for other components.

Benefits

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Benefits

There are many benefits to a vegetated swale, similar to other BMPs discussed in this document, including:

- improved water quality
- reduced runoff volume and rate
- increased groundwater recharge
- aesthetic enhancement
- more cost-effective than piping
- significantly slower rate of runoff conveyance compared to piping

Costs

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Cost Considerations

As with all other BMPs, the cost of installing and maintaining Vegetated Swales varies widely with design and site variability. In general, Vegetated Swales are considered relatively low cost control measures. Moreover, experience has shown that Vegetated Swales provide a cost-effective alternative to traditional piping and/or curbs and gutters. Generally speaking, Vegetated Swales cost between $4.50 and $8.50 per linear foot when vegetated from seed, and $15 to $20 per linear foot when vegetated from sod. Annual maintenance costs will be around $1 per linear foot (seed) and $2 per linear foot (sod). The expected lifetime of a Vegetated Swale is 50 years.

It is important to note that the costs listed above are only approximate. Also, these costs do not include the cost of activities such as clearing, grubbing, leveling, and filling, if required. The Southeastern Wisconsin Regional Planning Commission (SEWRPC, 1991) reported that actual costs, which do include these activities, may range from $8.50 to $50.00 per linear foot depending on swale depth and bottom width. When all pertinent construction activities are considered, it is still likely that the cost of Vegetated Swale installation is less than that of traditional conveyance elements. When annual operation and maintenance costs are considered however, swales may prove the more expensive option, though they typically have a much longer lifespan.

Ease of Development/Construction

The soil base for a vegetated swale must provide stability and adequate support for proposed vegetation. When the existing site soil is deemed unsuitable (clayey, rocky, coarse sands, etc.) to support dense vegetation, replacing with approximately 12 inches of loamy or sandy soils is recommended. Swale soils shall also be well-drained. If the infiltration capacity is compromised during construction, the first several feet shall be removed and replaced with a blend of topsoil and sand to promote infiltration and biological growth.

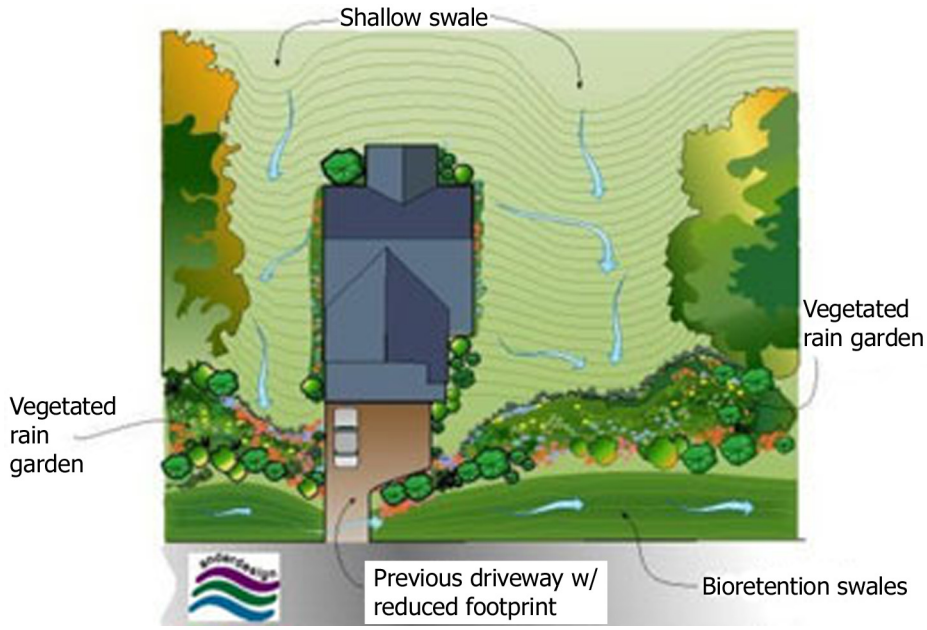

Image: Pierce County/WSU Extension, with modifications by Cahill Associates

Swales are most efficient when their cross-sections are parabolic or trapezoidal in nature. Swale side slopes are best within a range of 3:1 to 5:1 and shall never be greater than 2:1 for ease of maintenance and side inflow from sheet flow. To ensure the filtration capacity and proper performance of swales, the bottom widths typically range from 2 to 8 feet. Wider channels are feasible only when obstructions such as berms or walls are employed to prohibit braiding or uncontrolled sub-channel formation. The maximum bottom width to depth ratio for a trapezoidal swale should be 12:1. Vegetated Swales shall be designed to discharge to another BMP (rain garden, infiltration bed, etc), existing storm pipe, or outfall in a stabilized fashion.

Studies have shown that the maximum amount of swale filtering occurs for water depths below 6 inches. It is critical that swale vegetation not be submerged, as it could cause the vegetation to bend over with the flow. This would naturally lead to reduced roughness of the swale, higher flow velocities, and reduced contact filtering opportunities. Ideal swale vegetation shall consist of a dense and diverse selection of close-growing, water-resistant plants whose growing season preferably corresponds to the wet season. For swales that are not part of a regularly irrigated landscaped area, drought tolerant vegetation should be considered as well. Use of native plant species is strongly advised, as is avoidance of invasive plant species. Swale vegetation should also be salt tolerant, if winter road maintenance activities are expected to contribute salt/chlorides.

Image: Steve Roy, GeoSyntec Consultants

Vegetated Swales are generally constructed in the following sequence:

1. Rough grade the vegetated swale. Equipment shall avoid excessive compaction and/or land disturbance. Heavy excavating equipment should operate from the side of the swale and never on the bottom. If excavation leads to substantial compaction of the subgrade, 18 inches shall be removed and replaced with a blend of topsoil and sand to promote infiltration and biological growth. At the very least, topsoil shall be thoroughly deep plowed into the subgrade in order to penetrate the compacted zone and promote aeration and the formation of macropores (soil pore space). Following this, the area should be disked prior to final grading of topsoil.

2. Construct check dams, if required.

3. Fine grade the vegetated swale. Accurate grading is crucial for swales. Even the smallest nonconformities may compromise flow conditions.

4. Prior to establishment of vegetation, a swale is particularly vulnerable to scour and erosion and therefore its seed bed must be protected with temporary erosion control, such as straw matting, compost blankets, or fiberglass roving. Seed, vegetate and install appropriate protective lining as soon as possible. Plant the swale at a time of the year when successful establishment without irrigation is most likely. However, temporary irrigation may be needed in periods of little rain or drought. Vegetation should be established as soon as possible to prevent erosion and scour.

5. Once all tributary areas are sufficiently stabilized, remove temporary erosion and sediment controls. It is very important that the swale be stabilized before receiving upland stormwater flow.

Aesthetics

Aesthetics

In addition to providing conveyance, filtration, and infiltration of stormwater runoff, Vegetated Swales can greatly enhance the natural beauty of any site. By landscaping with trees and shrubs along side slopes, swales can be easily and aesthetically integrated into the overall site design without unnecessary loss of usable space. An important consideration however, is that tree plantings allow enough light to pass and sustain a dense ground cover. When the trees have reached maturity, they should provide enough shade to markedly reduce high temperatures in swale runoff.

Township Review

In most cases, there should be no need for special Township review, permitting actions, and so forth when Vegetated Swales are developed – unless the area being disturbed was quite large, thereby qualifying as an action which triggers related permits, reviews, approvals.

Site Constraints

The effectiveness of a vegetated swale is directly related to the contributing land use, the size of the drainage area, the soil type, slope, drainage area imperviousness, proposed vegetation, and the swale dimensions. Natural low points in the topography are ideal for swale location, as are natural drainage courses, though infiltration capability may be reduced in these locations. The topography of a site shall allow for the design of a swale with sufficiently mild slope and flow capacity. Swales are impractical in areas of extreme (very flat or steep) slopes and should be carefully integrated into properties in the steeply sloping Trout Creek subbasins. Of course, adequate space is required for vegetated swales. Slopes between 1% and 3% are generally recommended for swales. If the topography necessitates steeper slopes, check dams are suggested to reduce the energy gradient and erosion potential.

Siting of vegetated swales should take into account the location and function of other site features (buffers, undisturbed natural areas, etc.). Siting should also attempt to aesthetically fit the swale into the landscape as much as possible. Sharp bends in swales should be avoided. Where possible, swales shall be constructed in areas of uncompacted cut, not on slopes with fill material. Fill slopes can be prone to erosion and/or structural damage by burrowing animals.

Image: PA Stormwater BMP Manual

Variations

Grass Swale: Grass swales are essentially conventional drainage ditches. They typically have milder side and longitudinal slopes than their densely vegetated counterparts. Grass swales are usually less expensive than vegetated swales. However, they provide far less infiltration and pollutant removal opportunities.

Vegetated Swale with Check Dam: Check dams are recommended for vegetated swales with slopes greater than 3%. They are often added to enhance infiltration capacity (stormwater stores behind the check dams and soaks into the soil), decrease runoff volume, rate, and velocity, and promote additional filtering and settling of nutrients and other pollutants. In effect, check-dams create a series of small, temporary pools along the length of the swale. Swales with check-dams are much more effective at mitigating runoff quantity and quality than those without. The frequency and design of check-dams in a swale will depend on the swale length and slope, as well as the

desired amount of storage/treatment volume.

Check-dams are typically constructed to a height of 6" – 12" and are regularly spaced. The following materials can be employed for check-dams: natural wood, concrete, stone, and earth. Earthen check-dams however, are typically not recommended due to their potential to erode. In the case of a stone check-dam, two or more stone sizes may be used, provided a larger stone is placed on the downstream side, since flows are concentrated at the exit channel of the weir. Several feet of smaller stone can then be placed on the upstream side.

Vegetated Swale with Infiltration Trench: This option includes a 12" – 24" aggregate bed or trench, wrapped in a nonwoven geotextile (See Infiltration Trench BMP for further discussion.). This addition of an aggregate bed or trench substantially increases runoff control and water quality performance, though at an increased cost. Vegetated Swales with Infiltration Trenches are best fitted for milder sloped swales. The Infiltration Trench component should be comprised of flat, terraced levels, though mildly sloping trench bottoms may also be acceptable.

Maintenance

Maintenance

Compared to other stormwater management measures, the required upkeep of vegetated swales is relatively low. In general, maintenance strategies for swales focus on sustaining both the hydraulic and pollutant removal efficiency of the channel, as well as maintaining a dense vegetative cover. Experience has proven that proper maintenance activities ensure the functionality of vegetated swales for many years. The following schedule of inspection and maintenance activities is recommended:

Maintenance activities to be done annually or 48 hours after every major storm event (at least 3 times during the first year):

- Inspect and correct erosion problems, damage to vegetation, and sediment and debris accumulation (address when > 3 inches at any spot or covering vegetation)
- Inspect vegetation on side slopes for erosion and formation of rills or gullies.
- Inspect for pools of standing water.
- Mow and trim vegetation to ensure safety, aesthetics, proper swale operation, or to suppress weeds and invasive vegetation; dispose of cuttings in a local composting facility; mow only when swale is dry to avoid rutting
- Inspect for litter and remove as necessary.
- Inspect for uniformity in cross-section and longitudinal slope, correct as needed

- Inspect swale inlet and outlet for signs of erosion or blockage, correct as needed

Maintenance activities to be done as needed:

- Plant alternative grass species in the event of unsuccessful establishment
- Reseed bare areas; install appropriate erosion control measures when native soil is exposed or erosion channels are forming
- Rototill and replant swale if draw down time is more than 48 hours
- Inspect and correct check dams when signs of altered water flow (channelization, obstructions, etc.) are identified
- Water during dry periods, fertilize, and apply pesticide only when absolutely necessary

Winter conditions also necessitate additional maintenance concerns, which include the following:

- Inspect swale immediately after the spring melt, remove residuals (e.g. sand) and replace damaged vegetation without disturbing remaining vegetation.
- If road runoff is directed to the swale, mulching and/or soil aeration/manipulation may be required in the spring to restore soil structure and moisture capacity and to reduce the impacts of deicing agents.
- Use salt-tolerant vegetation in swales.

Image: PA Stormwater BMP Manual