Bioinfiltration Swale — BMP 2

Description

Bioinfiltration swales (BI swale) are depressions created by excavation, berms or small dams placed in channels intended to infiltrate the design storm runoff from impervious surfaces through a grass or vegetative root zone. Bioinfiltration swales represent a cross between a biodetention basin and a vegetated swale. They are designed for conveyance as well as infiltration.

Work done in Spokane County, Washington, on the adjoining Spokane Valley aquifer shows that infiltration of the design storm runoff from impervious surfaces provides treatment for approximately 90% of contaminant load carried in stormwater. The BMP 2 design is based on treatment of a precipitation rate of 0.10 inches per hour. This is expected to treat greater than 90% of flows and the design treatment flow of runoff from precipitation events in Kootenai County. The design flow will need to be adjusted for other areas based on precipitation records.

Applications

An open basin BI swale at the ground surface can be used where sufficient open space is available. This takes advantage of existing natural surface depressions and swales on the site where a berm or a low dam could very simply create the needed area. Alternatively, the landscape can be designed to include a depressed area in which to place the bioinfiltration swale. Road ditch areas are suited to use for bioinfiltration swales given the proper soil conditions.

Bioinfiltration swale (BI swale) construction involves proper soil profile modification, grading, and planting. The number, size, shape, construction, and planting of a BI swale should be suited to the slope, configuration, and human use of the site. Runoff can be delivered through a swale, armored flume, drop structure, or a buried culvert discharging directly to the basin floor. These structures can be designed to be consistent with the characteristics of the site.

The appropriate soil conditions for infiltration and the protection of ground water are the most important considerations limiting the use of this BMP. Soils should be permeable enough to infiltrate runoff but should also contain enough fine soils and organic material to remove pollutants and promote the growth of deep rooted, healthy vegetation. Planting soils should be at least loamy, with a clay content of less than 15%. The soil should contain 3-5% organic material and have a pH of 5.5 to 6.5 (Examples of appropriate soil types in Idaho are the Garrison, Avonville and McGuire soil types on the Rathdrum Prairie.). As with any type of infiltration facility, BI swales should not be used in areas with shallow aquifers used for drinking water. An official inventory form should be submitted to the Idaho Department of Water Resources (IDWR). Contact the closest regional office for further information.

Because soils can vary tremendously over short distances, site-specific evaluation may be required to determine if the minimum infiltration rate is attainable. If the tested infiltration rate cannot meet minimum values, more permeable material should be imported, and the soil profile should be modified to allow these swales to properly function.

Limitations

Drainage area – 5 ac.
Minimum bedrock depth – 6 ft
NRCS soil type – A, B
Drainage/flood control – yes
Max slope – 4%
Minimum water table – 3 ft
Freeze/thaw – fair

As with any type of infiltration facility, BI swales should not be used in areas with shallow aquifers. An official inventory form for shallow injection wells, used in association with the swales, should be submitted to the IDWR or, in some cases, the local health district. Contact the closest IDWR regional office for further information.

Targeted Pollutants

Sediment – 75%
Phosphorus – 30%
Trace metals
Bacteria
Hydrocarbons

Design Parameters

The following are general design parameters for bioinfiltration swales:

- Impervious surface area of a tributary area should be less than 1 acre
- Use several small BI swales rather than one large BI swale
- Dry-well rim elevation should be above the base of the BI swale to provide some assurance of infiltration of the design storm prior to overflow
- Planting soil depth of 4 feet. Adequate nutrient removal requires a minimum of 2.5 feet

The following specific design parameters given in this BMP have been developed as trial and error methods in Spokane County, Washington, and Kootenai County, Idaho. A technical advisory committee for stormwater design compiled this accumulated knowledge for the Rathdrum Prairie Aquifer, convened in the summer of 2000. Design parameters may need to be adjusted for other parts of the state due to variations in conditions.

Any design should keep in mind the leading causes of failure for BI swales:
1. Pre-silting during construction. This occurs generally after the contractor has roughed in the swales during the excavation phase of construction. Loose soil from the development is washed from the streets and off of building sites into the swales. This fine soil lowers the permeability to the point of swale failure, even though the original soil permeability was adequate.

2. Over-compaction of soils during construction. Equipment operated improperly in the swale will decrease swale permeability and may cause failure.

3. Improper incorporation of imported soils. Soils (e.g., topsoil, compost) imported for landscape development need to be properly incorporated into existing soils.

4. Excessive irrigation of grass. Vegetation in the swale is irrigated excessively to the point where almost constant soil saturation is occurring and when a rainfall event does occur the infiltration rate is not adequate.

Soils. Infiltration should be measured using ASTM D 5126 single ring infiltrometer test, but this is a local option. Soil infiltration capacity should be a minimum 0.5 inches per hour for the life of the swale. The maximum infiltration rate is 3.0 inches per hour. A higher maximum infiltration rate may be acceptable if an adequate vegetative cover can be maintained without excessive irrigation. Infiltration rate should be tested if the swale has the appearance of non-compliance with the required infiltration rate. This generally shows up as prolonged ponding around the dry-well intake.

Slopes. The BI swale should have slopes that do not result in erosive velocities for the design storm. This is usually less than or equal to 4% unless check dams (Volume 2, BMP #22) are installed.

Water Velocity. Water velocity as it enters and flows across the swale should not exceed the erosional velocity.

Shallow Injection Well (Dry well) Capacity. The outflow capacity of the dry wells should be based on the infiltrative capacity of the surrounding soil. The maximum design outflow capacity of a double-depth dry well is 1 cubic foot per second (cfs) and 0.3 cfs for a single depth unless it can be adequately demonstrated that the infiltrative capacity of the surrounding soil will allow for a greater capacity.

Dry well Rim Height and Placement. Infiltration swales should be designed to infiltrate the design flow before reaching the dry-well rim. Local jurisdictions will determine the minimum dry well rim height, but the rim should be elevated above the lowest point of the swale. The dry well should be placed as far as possible from any points of inflow.

Design Storm Treatment Area. The BI swale design storm intensity for the Rathdrum Prairie Aquifer (90 % of stormwater treated) is 0.1 inch (0.25 cm) per hour (Dobler, 2000). The minimum swale area is determined by matching the infiltrative capacity with the rate of flow into the swale. This calculation can be done incrementally with the Manning's flow equation (Chow, 1959 page 111). An acceptable method for calculating inflow into the swale from the impervious area is the rational method (Soil Conservation service). None of the design stormwater runoff should reach the dry well prior to infiltration for the design to be acceptable. Figure 2 is an illustration of the BI swale and accompanying dry well.

The county or municipality where the facility is located should provide the design storm for the facility and any minimum sizing requirements. Do not confuse the requirements for stormwater treatment with the need to control and dispose of extreme storm flows.

Vegetative Cover. The BI swale and associated side slopes should be vegetated. The species selected may vary to include both water-oriented native and non-native/domestic species. Trees and brushy buffer strips may also be used to slow water velocities and enhance infiltration. Non-native/domestic species should not be allowed to grow more than 3 inches in height when finally established. Water-oriented native species may be allowed to grow to its maximum un-mowed height to achieve the goals of both stormwater cleansing and those of the proposed landscape development component of the project.

If sod is chosen to vegetate the swale, select sod that has been grown in permeable soils. Sod grown in clay soils will not be effective because the clay soil can restrict water infiltration reducing the expected infiltration rate of the system. If sod grown in clay soils is the only sod available, ask the grower to wash off the soil from the sod to remove all clay material.

Construction Guidelines

Construction Schedule. The sequence of various phases of basin construction should be coordinated with the overall project construction schedule. A program should schedule rough excavation of the swale with the rough grading phase of the project to permit use of the fill in earthwork areas. The partially excavated basin may serve as a temporary sediment trap or pond in order to assist in erosion and sediment control during construction. However, swales near the final stages of excavation should never be used prematurely for runoff disposal. Drainage from untreated, freshly constructed slopes within the watershed area could load the newly formed basin with a heavy concentration of fine sediment. This could seriously impair the natural infiltration characteristics of the swale floor. Final grade of a BI swale should not be attained until after its use as a sediment control basin is completed. It is necessary to protect the dry well from siltation after installation.

Specifications for swale construction should state the earliest point in construction progress when storm drainage may be directed to the swales. Due to the wide variety of conditions encountered among projects, each should be separately evaluated in order to postpone use as long as reasonably possible.

The final phase of excavation should remove all accumulated sediment. Light, tracked equipment is recommended for this operation to avoid compaction of the swale floor.

Maintaining adequate infiltration rates is critical to the function of the grassed swale. An option to maintain infiltration rates is to over excavate the swale and fill with permeable soils (see design infiltration rates). After the final grading is completed, the swale floor should be scarified to provide a well-aerated, highly porous surface texture.

Soils imported for landscape development need to be properly incorporated into existing soils. This may include tilling the soils to a depth of 6 inches for optimal blending.

Infiltration Test. A double ring infiltrometer test (ASTM D5126) should be conducted (a local option) after final grading, and the determined rate of infiltration should be at a minimum 0.5 inches per hour. The maximum allowable rate is 3.0 inches per hour, unless it can be shown that a satisfactory vegetative cover can be maintained without excessive irrigation. Testing may be required by the local permitting agency to ensure infiltration rates are within the required range. Should the swale not meet the minimum infiltration rate of 0.5 inches per hour, more permeable material should be brought in and incorporated or replace the first 6 to 10 inches of the existing material and the infiltration test redone. If the soil cannot be treated to reach the minimum infiltration rate, an alternative design should be made.

Small-scale infiltration tests, such as a double ring infiltrometer, may not adequately measure variability of conditions in test areas and, if used, measurements should be taken at several locations within the area of interest. Soil pit excavation may still be necessary if highly variable soil conditions or seasonal high water tables are suspected. A pilot infiltration test or small-scale test infiltration pits may also be necessary for large facilities or to verify design infiltration rates for the local jurisdiction. If the infiltration rates are less than what was used for the system design, the system shall be reconditioned or redesigned to match the design infiltration rate.

Erosion and Sediment Control. A healthy stand of broad leaf grass should be established on the swale floor and slopes. This vegetation will prevent erosion and sloughing and will also provide a natural means of maintaining infiltration rates and removing pollution. Erosion protection of inflow points to the basin should also be provided (e.g., riprap, flow spreaders, energy dissipaters). Removal of accumulated sediment is a problem only at the basin floor. Little maintenance is normally required to maintain the infiltration capacity of side slope areas.

Maintenance

Goal. To ensure that the BI swale operates as designed by maintaining the infiltration and treatment capabilities of the physical and biological portions of the system.

Access. Provide enough access space for maintenance activities. Check with local permitting authority to determine if a dedicated maintenance easement is required for the BI swale.

Inspection. When BI swales are first placed into use, they should be inspected on a monthly basis and after large storm events. During the period October 15 though April 15, inspections should be conducted monthly. Thereafter, once it is determined that the basin is functioning in a satisfactory manner and there are no potential sediment problems, inspections can be reduced to a semi-annual basis with additional inspections following the occurrence of a large storm. Inspectors should check for functional inlet, erosion, condition of vegetation, ponded water, disposal of other waste in the swale or dry well, and conformance with original design.

Sediment Control. The BI swale should be designed with maintenance in mind. Access should be provided for vehicles to easily maintain the BI swale. Grass bottoms in BI swales seldom need replacement since grass serves as a good filter material. If silty water is allowed to trickle through the turf, most of the suspended material is strained out within a few yards of surface travel. Well-established turf on a swale floor will grow up through sediment deposits forming a porous turf and preventing the formation of an impenetrable layer. Grass planted on swale side slopes will prevent erosion.

Vegetation Maintenance. Maintenance of vegetation established on the BI swale floor and side slopes is necessary in order to promote dense turf with extensive root growth to enhance infiltration, prevent erosion and consequent sedimentation, and prevent invasive weed growth. Bare spots should be immediately stabilized and re-vegetated.

If the intent of the finished look of the BI swale is that of maintained turf grass, mowing at regular intervals will be required to keep the grass at 3 inches or less in height. Clippings should be collected as they contribute to a decline in BI swale porosity. If the intent of the finished look of the BI swale is more natural through the use of native plants, regular mowing will not be necessary. However, at the end of the growing season native grasses should be cut to a height of 3 inches, collected, and removed to maintain an optimal level of BI swale porosity. Fertilizers should be applied only as necessary and in limited amounts to avoid contributing to the pollution problems that the swale is intended to solve. Excessive irrigation should be avoided as saturated soils have a lower infiltration capacity than dry soils, and the intent of the swale is to infiltrate water from the drainage area.

Additional Information

This swale BMP for the Rathdrum Prairie Aquifer was created by a Technical Advisory Committee (TAC) convened in June 2000. The BMP was completed in December 2000 for inclusion into the *Catalog of Best Management Practices for Idaho Cities and Counties*. Revised: April 2004.

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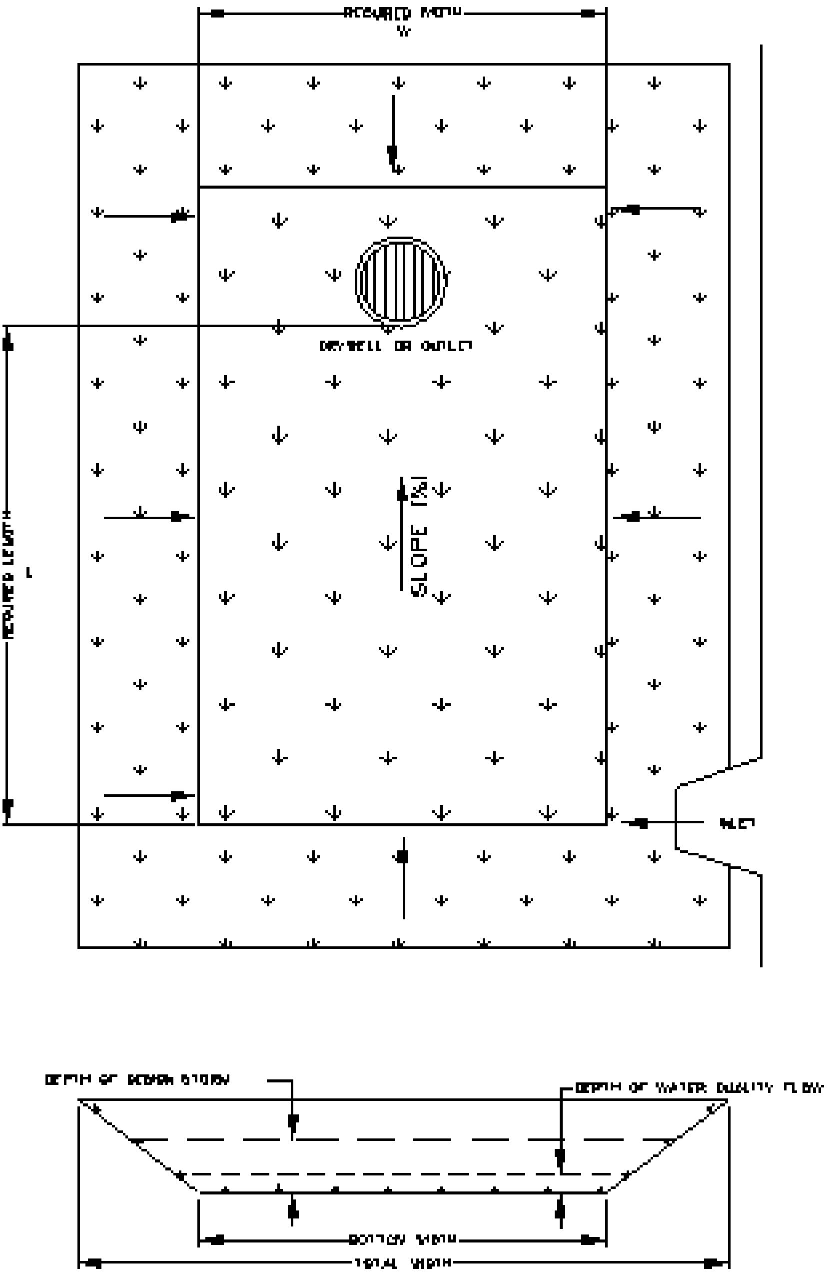

TRAPEZOIDAL CROSS SECTION

Figure 1 - Example of a grassed infiltration area showing characteristics used in design equations.