5.3.7 Infiltration Berms

Description

Infiltration berms are compacted linear mounds of earth constructed along contours that are used to reduce stormwater velocities and detain runoff volume on hillsides with gentle to moderate slopes. By creating gentle variations in the topography of a hillside, infiltration berms slow the flow of runoff to allow ponding on the soil surface and storage of runoff in modified soils or in a stone trench, and promote infiltration behind the berm. Infiltration berms can aid in slope stabilization and prevent erosion, add interest to uniform landscapes, filter pollutants in runoff, and create habitat. Infiltration berms are often referred to as retentive grading. Infiltration berms may be used in conjunction with vegetated swales (Section 5.3.5) or infiltration trenches (Section 5.3.3) to provide additional stormwater management.

Figure 5.3.7-1. Infiltration berm constructed along the contour in a wooded area receives runoff from a large-lot residential area.

BMP Functions Table

BMP	Applicability	Volume Reduction	Water Quality	Peak Rate Reduction	Recharge	Runoff Temperature Mitigation	Heat Island	Habitat Creation	Maintenance Burden	Cost
Infiltration Berm	S/R	H	H	H	H	M	M	M	L	L

KEY: U = Urban; S = Suburban; R = Rural; H = High; M = Medium; L = Low

Key Design Features

- Infiltration berms should be constructed parallel to contours to intercept and detain runoff.
- The end sections of the berm should taper into the uphill grade to prevent flow channelization around the ends of the berm.
- An overflow weir or bypass mechanism must be provided for larger storms.
- On the uphill side of the infiltration berm, surface ponding, modified soils, and/or an infiltration trench should be used to capture and infiltrate stormwater.
- The depth of ponding behind berms should be limited to 6 inches or less.
- The maximum side slope of berms should be 3:1; 4:1 if they are to be mowed.
- The berm core is keyed and compacted to prevent berm failure, but covered with topsoil and densely planted.
- Preferably, berms should be vegetated with tall grasses, shrubs, and trees, but at a minimum, must be planted with turf.
- Infiltration berms can be used as a standalone BMP or as pretreatment for other BMPs (such as a vegetated swale or bioretention area).
- The berms must be carefully constructed along a contour to avoid low points where overflow may concentrate and erosion may occur.
- The use of turf reinforcement mats (TRMs) or other stabilization materials will prevent erosion of the berms.
- Infiltration berms should only be used to treat small, localized drainage areas (generally less than 5,000 square feet), and usually complement other BMPs as part of a treatment train and volume reduction system.
- Subsoils excavated from behind berms can be used for berm core construction. These soils can also be modified in place uphill of the berm to increase absorptive properties for stormwater volume storage.
- Infiltration berms can be used on already vegetated hillsides with trees if care is taken not to disturb existing root structures.

- Berms can be placed in series along parallel contours to break up large drainage areas into smaller sub-drainage areas.

Figure 5.3.7-2. This berm is combined with an infiltration trench (BMP 5.3.3) to capture runoff from a grassed overflow parking area.

Applications

- Best suited for less densely developed areas, on vegetated hillsides.
- Used in inactive park space and other open space to receive runoff from compacted pervious areas.
- Used for slope stabilization and erosion prevention.
- Can be used in combination with other BMPs (especially in highly impervious areas).
- Can be used as pretreatment for other BMPs (such as vegetated swale or bioretention area).

- Best applied on gentle to moderate slopes (15 percent or less).
- Used to receive runoff from roof leaders or divisions between individual lots.

Advantages

- Integrates stormwater into landscape.
- Improves aesthetics.
- Designed to decrease the velocity of runoff from small storms, improve water quality, and provide volume reduction.
- Cost-effective.
- Low-maintenance and minimal structure requirements.

Disadvantages

- Infiltration requires suitable site conditions.
- Vegetation and soils must be protected from damage and compaction.
- Salt use on tributary pavements may impact berm vegetation and soils.
- Vegetation must be firmly established and densely spaced to avoid potential for erosion.
- Applicable only to small drainage areas.
- **Must** be constructed properly to avoid creating conditions of concentrated flow.

Variations

- **Live Fascine Bundles** are a variation to infiltration berms used for slope stabilization, velocity reduction, and erosion control. Live Fascine Bundles are bundles of live cuttings of woody plant species installed in shallow trenches at regular intervals along hillsides and secured with live stakes. They provide soil stabilization with their root structure and increase surface roughness to intercept and slow the velocity of stormwater runoff and also reduce erosion. For details on the construction of Live Fascine Bundles, see the *USDA & NRCS Engineering Field Handbook (1992),* Chapter 18, Soil Bioengineering for Upland Slope Protection and Erosion Reduction, for guidance.

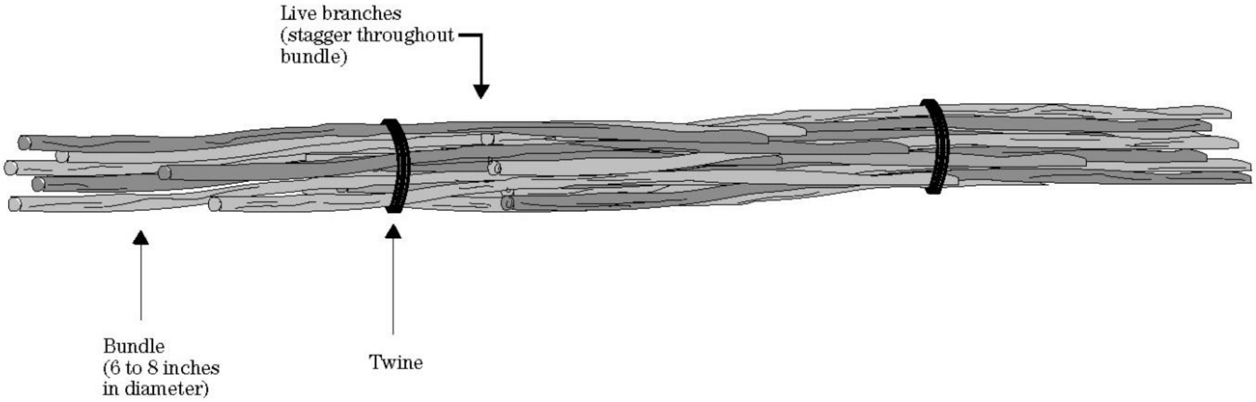
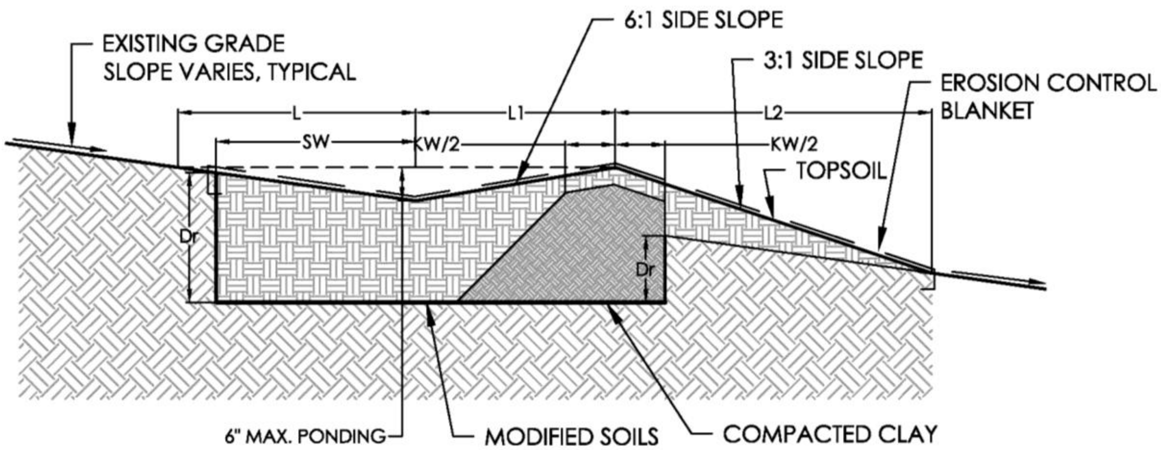


Figure 5.3.7-3. Typical Live Fascine Bundle (*USDA & NRCS Engineering Field Handbook).*

Applicable Protocols and Specifications

The following Protocols and Specifications (see Appendices A through F) are applicable to infiltration berms and must be addressed:

- Protocol 1 Setbacks from Structures
- Protocol 2 Coordination with Other Utilities
- Protocol 3 Site Evaluation and Infiltration Testing
- Protocol 4 Infiltration System Guidelines
- Protocol 5 Planting and Mulching Guidelines
- Appendix F
  - Stormwater System Specifications
  - Bioretention Soil Specifications
  - Aggregates and Drainage Layers
  - Pipes
  - Control Structures
  - Geotextiles



INFILTRATION BERM SECTION
FIGURE 5.3.7-4a NTS

Drainage Area	Existing Slope, %	Berm Length	Sideslope, L1	Sideslope, L2	Ponding Depth, PD	L	Ponding Width	Top Soil Depth, TSD	Soil Depth at left, Dl	Soil Depth at right, Dr	Key Width, KW	Soil Width, SW
		(ft)	ft	ft	(in)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)
1	13.0%	232	3	4.40	6	3.82	6.82	0.25	1.99	1	1.5	3.00
2	10.0%	82	3	3.44	6	4.98	7.98	0.25	1.88	1	1.5	5.74
3	5.2%	77	3	2.33	6	9.61	12.61	0.25	1.70	1	1.5	6.00

Figure 5.3.7-4. An infiltration berm's dimensions are determined by the surface slope. For proper construction and quantification of volume management, the berm dimensions must be specified as indicated in the example table.

Design Considerations for Infiltration Berms

If designed to meet the specific needs of the site, an infiltration berm is an effective BMP that typically accompanies other BMPs in a larger stormwater management system.

1. Location and Capture Area

- Infiltration berms should be located on gentle to moderate slopes (15 percent or less).
- Infiltration berms should be located to prevent vegetation damage and soil compaction due to pedestrian traffic or unintended vehicle compaction.
- Optimum infiltration berm locations are often areas that are generally “unused” along slopes of woodlands and meadows, parks, public playgrounds, school yards, plazas, and courtyards, and in place of traditional landscape planting areas around buildings and structures.

2. Entrance/Flow Conditions

It is important for flow to enter an infiltration berm in a distributed flow or as sheet flow. Generally, runoff flows to infiltration berms through dispersed surface sheet flow along a depressed curb, lawn area, or edge of pavement, or down a hillside. Careful grading is essential to prevent a concentrated flow point and potential erosion. Concentrated flows of runoff should always be avoided to prevent erosion, gully formation, and preferential flow paths. When runoff travels across a surface for long distances, flows can begin to concentrate. For pervious contributing areas, flow path lengths greater than 150 feet should be avoided. For impervious contributing areas, flow path lengths greater than 100 feet should be avoided.

3. Management of Sediment, Trash, and Debris

In areas of high sediment load, infiltration berms should include measures to prevent the movement of material toward the berm and infiltration area.

During the establishment of vegetation, temporary erosion control blankets (ECBs) should be placed over the berm and infiltration area. If infiltration berms are placed in areas with relatively high runoff velocities where channelization is evident or where soils are currently eroding, it may be appropriate to use permanent turf reinforcement mats.

Any trash or debris that collects behind the berm should be removed regularly.

4. Storage and Stay-on-Volume

An infiltration berm may be designed to capture SOV, but very often it may only be able to capture a portion of the SOV. In this situation, the remaining SOV and water quality volume must be managed by downstream BMPs.

An infiltration berm provides volume management within the surface ponding area and the modified soil area.

Storage Volume (ft^3) = Surface Water Volume + Soil Storage Volume

Surface Water Volume: Available surface water storage behind the berm (always equal to or less than 6 inches deep). The designer should consider the bed side slopes when estimating volume.

Soil Storage Volume: The bioretention soil volume x void space ratio of 0.20. Again, slopes will affect the berm geometry and corresponding volume.

5. Area and Dimensions

In addition to reducing runoff velocities, the goal of infiltration berms is to detain stormwater volume upgrade, or "behind," the berm. This can be achieved by ponding water on the surface, by modifying the soils to increase their absorptive capacities, and/or by constructing an infiltration trench. The dimensions of ponding depth, modified soil depth and width, and infiltration trench depth and width behind the berm are a function of the quantity and velocity of the stormwater it is intended to receive, as well as other site conditions such as slope and soil type.

In general, infiltration berms should meet the following guidelines:

- Infiltration berms should be no higher than 6 inches to encourage infiltration and prevent excessive ponding behind the berm.
- Topsoil or planting soil should be placed over the compacted portion of the berm with a depth (at least 3 inches) sufficient for plant establishment.
- Individual berm length will depend on functional need and site size.
- Modified soil dimensions along the uphill side of the berm will vary based on runoff volume. Generally, modified soils are between 1 and 2 feet deep and can vary in width from 1 to 10 feet. It is recommended that excavated onsite soil be modified with compost and sand if necessary to limit the need to import soils.
- If an infiltration trench is used for stormwater volume storage, it should be designed using the guidelines in Section 5.3.3, Infiltration Trenches. Soil testing is not required for berms located within existing woodland, but soil maps/data should be consulted when siting the berms.
- Infiltration testing must be performed in accordance with Protocol 3 (see Appendix C) when infiltration is proposed for reduction of SOV.
- In all cases, the soils in the infiltration footprint should be protected from compaction.
- If a berm is to be mowed, the slope should not exceed a 4:1 ratio (horizontal to vertical) in order to prevent "scalping" by mower blades. If trees are to be planted on berms, the slope should not exceed a 5:1 to 7:1 ratio. Other herbaceous plants, which do not require mowing, can tolerate slopes of up to 3:1.

6. Overflow and Peak Rate

All infiltration berms must provide a safe way for water to overflow or bypass the system when large storms generate more stormwater runoff than the berm can hold. Overflow must be routed across undisturbed areas.

In the event that an infiltration berm is not sized to fully capture the first 1.0 inch (or 1.6 inch) of rainfall volume from its drainage area, it should overflow to a complementary BMP downstream. In all cases, infiltration berms should be designed so that water overflows uniformly across the crest of the berm and so that no points of concentrated flow are formed along the top or at the edges of the berm.

Infiltration berms do not usually have sufficient capacity for significant detention storage/mitigation, but may be credited for site peak rate control as described below.

Peak Rate Control and Infiltration Credit

For the purposes of site peak rate control, the designer may adjust the Curve Number value based on the volume managed by both the SOV and the infiltration volume that occurs during a portion of a 24-hour storm event. This will allow the designer to account for runoff that was captured by applying low-impact development and to formulate a representative lower Curve Number. This is described in Chapter 7.

When adjusting the Curve Number, the infiltration volume can be estimated as the infiltration that occurs during 12 hours of a 24-hour design storm. The infiltration area is the bottom area of the modified soils and does not include the berm itself.

7. Infiltration Berm Soils

There are three soil considerations for infiltration berms:

- The conditions of the native subsoil in the infiltration footprint
- The modified soils used for stormwater volume storage
- The soil used in berm construction

When excavating for infiltration berm construction, it is essential that the native subsoil within the infiltration footprint is not compacted with construction equipment. If the native soil is compromised during construction, the soils should be restored using the guidelines in Section 5.4.3, Restore and Amend Disturbed Soils.

If soil behind the berm is intended to store stormwater, it should be modified in accordance with Appendix F – Bioretention Soil Specification. If an inadequate soil specification is used, or if the modified soils are prepared, installed, or maintained poorly, runoff may infiltrate either too quickly or not quickly enough. If the soil infiltration rate is too low, the result is runoff overtopping the berm and exiting without treatment or detention. If the soil infiltration rate is too high, runoff will not have enough contact with the soil media to provide adequate water quality treatment, and there may be difficulty maintaining healthy vegetation.

8. Water Quality/Total Suspended Solids

Infiltration berms that can capture and manage the required SOV through infiltration are considered to meet all water quality requirements. See Chapter 7 for additional discussion about water quality improvement.

Construction Considerations

For the best success, infiltration berms should not be installed until site construction is complete and site stabilization has occurred. Infiltration berms completed before site stabilization **must** be protected from receiving sediment-laden runoff. Direct runoff around completed infiltration berms until site stabilization has occurred. Do not allow sediment-laden water to flow into berm infiltration footprints.

Construction Sequence Example

The following construction sequence is for an infiltration berm without a subsurface stone infiltration trench. If a stone infiltration trench is desired, the sequence should be modified to incorporate the guidelines in Section 5.3.3, Infiltration Trenches.

Step 1 Excavate Berms

a. Do **not** compact or subject existing subgrade in the infiltration footprint to excessive construction equipment traffic. Protect areas from vehicle traffic during construction with construction fence, silt fence, or compost sock.
b. Rough grade the infiltration berm area, avoiding compaction in the infiltration footprint behind the berm.
c. Remove fine materials and/or surface ponding in the infiltration footprint, caused by erosion, with light equipment and scarify underlying soils to a minimum depth of 6 inches with a York rake or equivalent by light tractor.

d. Halt excavation and notify the engineer immediately if evidence of sinkhole activity, unanticipated bedrock or groundwater conditions, or other site conditions are encountered that may affect infiltration bed design or performance.

Step 2 Install Infiltration Berms

a. Construct and fine grade berms to line, grade, and elevations indicated. Accurate grading is essential for infiltration berms. **Even the smallest nonconformities may compromise flow conditions.** Fill and lightly regrade any areas damaged by erosion, ponding, or traffic compaction.
b. Place the modified bioretention soils uphill behind the berm to the dimensions indicated. Lightly scarify the soil before placing modified bioretention soil.
c. Place planting soil immediately after approval of berms and bioretention soils. Any accumulation of debris or sediment that takes place after approval of subgrade shall be removed prior to installation of planting soil.
d. Install planting soil and lightly compact (tamp with backhoe bucket). Keep equipment movement over planting soil to a minimum – do not over compact. Install planting soil to grades indicated on the drawings.
e. Complete final grading of the berm after the top layer of soil is added. Lightly tamp down soil and smooth sides of the berm. The crest and base of the berm should be level along the contour.
f. Seed and vegetate according to plans, and stabilize topsoil. Plant the infiltration berm areas at a time of the year when successful establishment without irrigation is most likely. 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.
g. Stabilize freshly seeded berms with appropriate temporary or permanent soil stabilization methods, such as erosion control matting or blankets. Erosion control for seeded swales shall be required for at least the first 75 days following the first storm event of the season. If runoff velocities are high, consider sodding the swale or diverting runoff until vegetation is fully established.
h. Mulch planted and disturbed areas with compost mulch to prevent erosion while plants become established.
i. Protect infiltration berms from sediment at all times during construction. Silt fences, diversion berms, and/or other appropriate measures shall be used at the toe of slopes adjacent to infiltration berms to prevent sediment from washing into these areas during site development.
j. When the site is fully vegetated and the soil mantle stabilized, notify the engineer. The engineer shall inspect the infiltration berm drainage area at his/her discretion before the area is brought online and sediment control devices removed.

Operations and Maintenance

Infiltration berms require relatively low maintenance. However, if localized erosion develops, it must be addressed immediately.

- Inspect for uniformity in cross-section and longitudinal slope, especially along the top and at the edges of the berm, and correct irregularities causing concentrated flow conditions as needed.
- While vegetation is being established, pruning and weeding may be required.
- Detritus may need to be removed approximately twice per year. Perennial grasses can also be cut down or mowed at the end of the growing season.
- Infiltration berms should be inspected annually for sediment buildup, erosion, vegetative conditions, etc.
- Mow and trim vegetation to ensure safety, aesthetics, and proper berm operation, or to suppress weeds and invasive species; dispose of cuttings in a local composting facility; mow only when the berm is dry to avoid rutting.