

Summary Fact Sheet

Category: 1.0 Bioretention Systems

Practice: 1.3 Bioslopes

General Description: Bioslopes, also known as ecology embankments, are modified filter strips that contain a special soil called an ecology mix to improve water quality, reduce the runoff volume, and reduce the tendency for rill erosion to occur. They can be incorporated into standard fill slopes and resemble a basic grass filter strip when completed. Like bioretention cells, bioslopes promote infiltration, retain runoff volume, and use a variety of physical, chemical, and biological processes to reduce runoff pollutant loadings. They are designed as flow-through devices.

Water Quantity Controls

Bioslopes designs are based on the ability of the slope area to absorb and treat a specific design storm intensity. The design rainfall intensity typically corresponds to the maximum anticipated intensity of the water quality storm event. For storms with an intensity greater than the design rainfall intensity, some runoff will not be captured and infiltrated, but instead will flow over the surface of the bioslope. This is because for such storms, the flow rate from the drainage area exceeds the design flow rate through the bioslope.

Stormwater not captured by the bioslope can be detained through auxiliary surface or subsurface storage at the base of the bioslope. A ponding area or gravel storage bed (similar to an infiltration trench) can be constructed at the base of the bioslope to store excess runoff. It is important to emphasize that storm intensity, not rainfall depth, will determine the volume of “excess” stormwater that will need to be stored at the base of the bioslope. For the bioslope itself and the auxiliary storage area, the permeability of the subsoil will determine whether captured runoff will exfiltrate into the subsoil or flow into an underdrain connected to a conventional conveyance system.

Additional subsurface storage can be provided within the bioslope itself by enlarging the gravel underdrain trench. This can be used to store water that would otherwise flow directly into the underdrain pipe.

Water Quality Controls

The Washington State Department of Transportation has found that bioslopes can remove 60% of phosphorus, 77% of metals, and 88% of total suspended solids (TSS).

Location: Bioslopes are appropriate for use on medians and side slopes of access roads or sites. Bioslopes cannot be used where the side slope exceeds 4H:1V, or on unstable slopes. To avoid erosion, runoff must flow onto the bioslope via sheet flow only. High velocity and high discharge flows should be diverted to conveyance channels.

Design Construction and Materials: Bioslopes consist of a gravel level spreader adjacent to the pavement to evenly distribute flows and trap sediments, an optional vegetated filter strip to provide additional pretreatment if space allows, an ecology mix bed which provides the majority of water quality improvement, and an optional gravel underdrain trench with an underdrain pipe. Underdrains may be needed on Hydrologic Soil Group (HSG) C and D soils. Observation /

cleanout wells should be installed if underdrains are used. Soil amendments may be applied in the filter strip to increase its permeability.

When sizing a bioslope for its drainage area, the long-term flow rate through the ecology mix must be at least as great as the design peak discharge rate from the drainage area. Include a 50% safety factor when assigning a long-term conductivity rate to the ecology mix.

Equation 1:

$$(I_{\text{drainage area}} * \text{Area}_{\text{drainage}}) < (LTIR * \text{Area}_{\text{bioslope}})$$

- $Q_{\text{drainage area}}$ = design flow rate from the drainage area (cfs)
- $Q_{\text{infiltration}}$ = design long-term flow rate through the bioslope (cfs)
- $I_{\text{drainage area}}$ = design rainfall intensity (in/hr)
- $LTIR$ = long-term infiltration rate through the ecology mix bed (in/hr)
- $\text{Area}_{\text{drainage}}$ = drainage area size (ft²)
- $\text{Area}_{\text{bioslope}}$ = area of bioslope that treats $\text{Area}_{\text{drainage}}$ (ft²)

Because a bioslope is as long as the drainage area it is intended to treat, the width of the bioslope can be determined as follows.

Equation 2:

$$\text{Bioslope width} = (\text{average width of drainage area}) * (I_{\text{drainage area}} / LTIR)$$

Basic bioslope dimensions are given below.

- The bioslope parallels the sloped edge of the drainage area (e.g. roadway) and should be as long as the drainage area it is intended to treat.
- The bioslope width must be sufficient to provide treatment for the adjacent drainage area.
- Dual bioslopes must be at least 2' wide.
- The ecology mix soil bed should be 1' deep or greater.
- The side slope of the bioslope should be no steeper than 4H:1V.
- The gravel level spreader should be at least 1' wide and at least 18" deep.
- The gravel underdrain trench should be at least 2' wide.

Bioslopes consist of the following cost components.

Item	Unit	Estimated unit cost (2005 Dollars)
Gravel (for level spreader)	C.Y.	\$30 - \$35
Filter fabric	S.Y.	\$1 - \$5
Gravel (for underdrain trench)	C.Y.	\$30 - \$35
8" dia. perforated underdrain pipe	L.F.	\$8 - \$15
Grass seed or sod	M.S.F.	\$15 - \$20
Ecology mix	C.Y.	\$40 - \$60

The ecology mix consists of the following components (per WSDOT standards).

Component	Quantity
Mineral aggregate Crushed screenings 3/8" to #10 sieve	3 C.Y.
Perlite (horticultural grade): >70% larger than 18 mesh <10% smaller than 120 mesh	1 C.Y. per 3 C.Y. mineral aggregate
Dolomite #0, gradation #16 sieve	10 lb per C.Y. perlite
Gypsum #0, gradation #8 to #16 sieve	1.5 lb per C.Y. perlite

Cost: The cost for a bioslope to treat runoff from ½ impervious acre is comprised of both the installation cost and annualized costs. These cost calculations were based upon a bioslope with a surface area of 3,000 ft². A bioslope is assumed to have a lifespan of 25 years, at which point it will be removed and replaced.

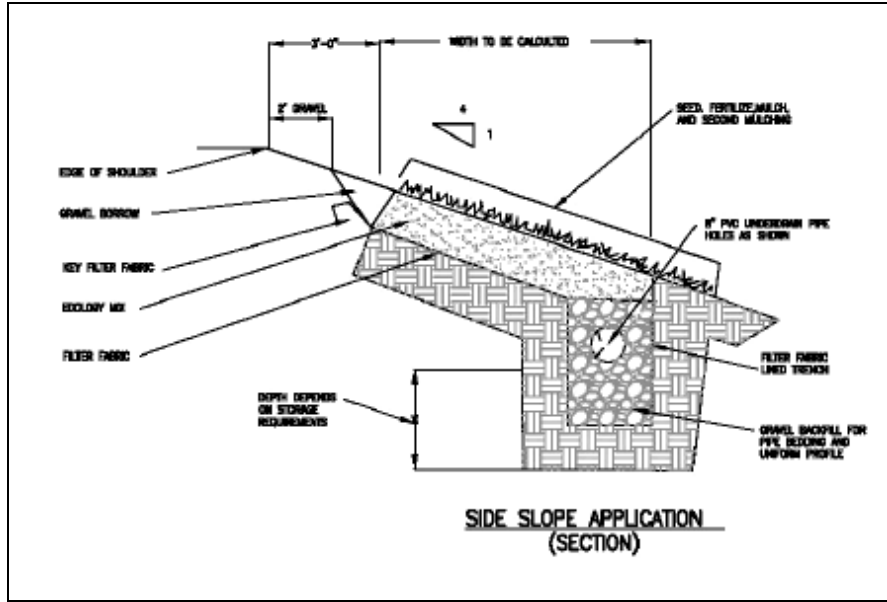
Item	Required Cost per Year (2005 Dollars)													
	0	1	2	3	4	5	6	7	8	9	10	...	25	
Installation ¹	10,000													
Mowing		150	150	150	150	150	150	150	150	150	150	150		
Reseeding		50	50	50	50	50	50	50	50	50	50	50		
Remove & Replace														10,000
Total Cost	10,000	200	200	200	200	200	200	200	200	200	200	200		10,000
Annualized Cost	\$600 / year (includes replacement in year 25)													

¹Developer Cost. Not included in annualized cost.

Maintenance: Periodically remove any debris that has accumulated on the gravel level spreader and mow the grass filter strip. Use a retractable-arm mower to avoid compacting the ecology mix. Both activities can be incorporated into regular maintenance activities. Reseed bare areas annually. Periodic conductivity tests may be used to determine whether the permeability of the ecology mix has decreased over time.

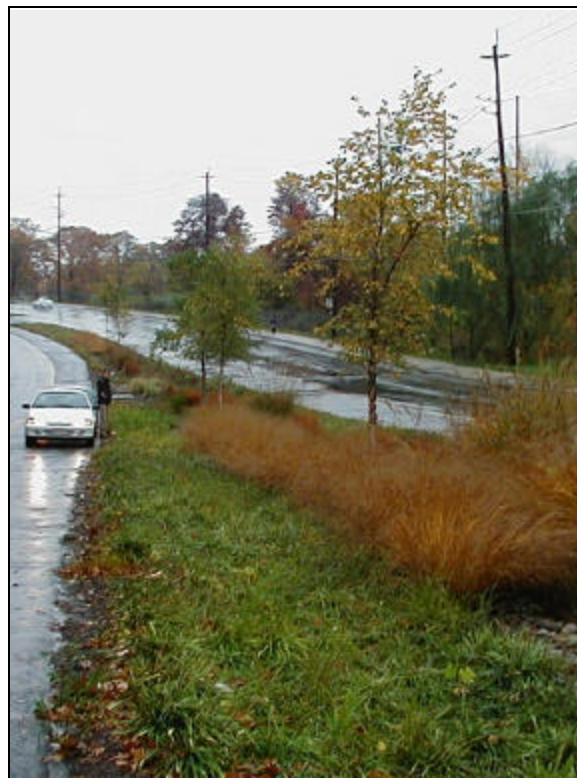
Performance and Inspection: To ensure proper performance, visually inspect that stormwater is infiltrating properly into the bioslope. Channelized flow down the slope or rill formation indicate operational problems. Corrective measures include inspection for accumulated sediments around the level spreader and removal, if necessary. Samples of the ecology mix should be taken in the case of poor infiltration to determine the condition of the ecology mix. Replacement of the bioslope ecology mix may be required if the mix condition has deteriorated. Perform this inspection:

- annually in spring, and
- after extreme events (e.g., after hurricanes).



Bioslope cross-section

Source: *Washington State Highway Runoff Manual*



Potential bioslope location in highway median

Source: *LID Center*

Potential LEED Credits:

Primary: Sustainable Sites – Credit 6 “Stormwater Management” (1-2 Points)

Other: Sustainable Sites – Credit 7 “Landscape & Exterior Design to Reduce Heat Islands” (1-2 Points)

Water Efficiency – Credit 1 “Water Efficient Landscaping” (1-2 Points)
Innovation & Design Process (1-4 Points)

Links to Additional Information:

Dawson, E., and J. Cammermeyer. A cheaper way to treat runoff. *Seattle Daily Journal of Commerce*, 16 Sep. 2004. Available at <http://www.djc.com/news/co/11161147.html>

Fairfax County Department of Public Works and Environmental Services. 2001. “Stormwater runoff quality control criteria.” *Public Facilities Manual*, 6-0400. Available at <http://www.co.fairfax.va.us/dpwes/publications/pfm/6-0400.htm>

Washington State Department of Transportation. Conditional short-term and pilot use designations for WSDOT's ecology embankment, 24 July 2003. Available at http://www.ecy.wa.gov/programs/wq/stormwater/newtech/cud_for_dot_ecy_embankment.pdf

Washington State Department of Transportation. 2004. *Highway Runoff Manual*, 5-69.