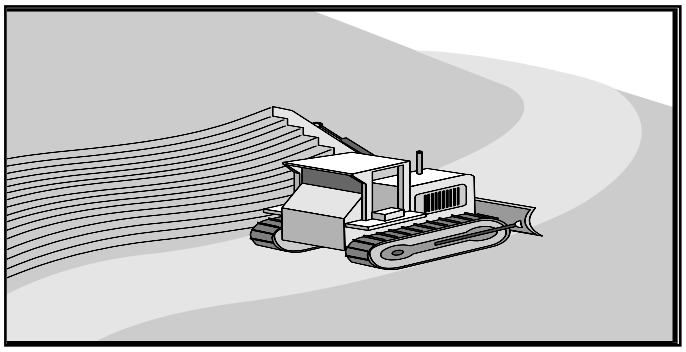
**ACTIVITY:** Gradient Terraces | ES – 04



CITY OF KNOXVILLE

| Targeted Constituents | | | | |
|---|---|---|---|---|
| ● Significant Benefit | ◗ Partial Benefit | ○ Low or Unknown Benefit | | |
| ● Sediment | ○ Heavy Metals | ○ Floatable Materials | ○ Oxygen Demanding Substances | |
| ○ Nutrients | ○ Toxic Materials | ○ Oil & Grease | ○ Bacteria & Viruses | ○ Construction Wastes |

**Description**

Terraces prevent or reduce the discharge of pollutants to the storm drain system or to watercourses as a result of construction activity by decreasing runoff velocities, trapping sediment, increasing infiltration, and supporting the establishment of vegetative cover. This management practice is likely to create a significant reduction in sediment.

**Suitable Applications**

- Slopes steeper than 3:1 (H:V) and greater than 5 feet in height, which are not part of a trench or excavation.
- Graded areas with smooth hard surfaces or any cleared area prior to permanent seeding and planting.
- Where length of slopes need to be shortened by terracing. Note: terracing is usually permanent and should be designed under the direction of and approved by a licensed professional civil engineer based on site conditions. Terraces must be designed with adequate drainage and stabilized outlets.

**Approach**

- Terraced slopes, as well as any slopes which are steeper than 3:1, should be designed by a licensed professional civil engineer based upon actual site conditions. Adequate drainage channels and diversions must be provided.
- Terraces and benches are commonly used in trenches or excavations as a means of providing slope stability. It is extremely important that trenches and excavations meet all of the Occupational Safety and Health Administration (OSHA) regulations in 29 CFR 1926, Subpart P – Excavations, latest edition. The gradient terraces in this BMP are intended for slopes and hillsides, not for use in trenches and other excavations.
- Graded areas with smooth, hard surfaces give a false impression of "finished grading" and a job well done. It is difficult to establish vegetation on such surfaces due to reduced water infiltration and root penetration. Rough surfaces with uneven soil and rocks left in place may appear unattractive or unfinished at first, but they encourage water infiltration, speed the establishment of vegetation, and decrease runoff velocity. Rough, loose soil surfaces give lime, fertilizer, and seed some natural coverage and favorable moisture levels that aid seed germination.
- If terraced slopes become unstable due to diverted runoff patterns, then alternative measures should be considered. Alternative measures can include flow diversion,

drains, swales, level spreaders, geotextiles, and bank stabilization practices as described in the ES section of the BMP Manual.

**Application**

There are several ways to create a gradient terrace that will meet slope stability requirements. Factors to be considered are the steepness of slope, mowing requirements, and whether the slope is formed by fill or by excavation. Generally, a slope cannot be mowed if it is steeper than 3:1 (H:V).

The following methods are shown in the attached figures:

Figure ES-04-1 Contour furrow
Figure ES-04-2 Serrated slope
Figure ES-04-3 Stepped slope, terraced slope

There are also different methods for achieving a roughened soil surface on a slope, and the selection of an appropriate method depends upon the type of slope. Roughening methods include grooving and tracking. The use of different equipment in various areas may be used to accomplish different levels of compaction or roughening.

***Contour Furrows***

Contour furrows may be used for slopes which are 3:1 (H:V) or flatter. Diversion berms or channels may be necessary at the top of slope and along the edges of the slope in order to prevent concentrated stormwater runoff from eroding the slope. The maximum distance between furrows shall be 40 feet, and the maximum slope length shall be 200 feet.

***Serrated Slopes***

A serrated slope may be used for slopes which are 2:1 (H:V) or flatter. This type of gradient terrace is labor-intensive in that bladed equipment will be needed to make numerous passes along a slope, beginning at the top and working downward. The maximum slope length shall be 100 feet.

***Stepped Slopes***

Graded areas steeper than 3:1 (H:V), which will not be mowed, should preferably have a stepped slope as in Figure ES-04-3. The stair-stepping effect will help vegetation become attached and also trap soil eroded from the slopes above. Stepped slopes are particularly appropriate in soils containing rock. Each step catches rocky material, which sloughs from above, and provides a level site where vegetation can become established.

Steps should be wide enough to work with standard earth moving equipment. Preferably the horizontal distance should be at least 1.5 times the vertical cut distance. Slightly grade the horizontal bench inwards (e.g. back towards the top of slope). Do not make individual vertical cuts more than 24 inches high in soft materials or more than 3 feet high in rocky materials. Groove the slope using machinery to create a series of ridges and depressions that run across the slope and on the contour.

***Terraced Slopes***

Terraced slopes are preferable for longer slopes that will be regularly mowed. A designed drainage channel is located within the terraces at regularly spaced intervals. The designed drainage channel shall have a regular cross section that includes slope and depth requirements. It may be necessary to locate intersecting channels to safely convey stormwater to the bottom of the slope. The intersecting channels typically incorporate

downdrains, riprap, energy dissipators, stilling basins, concrete aprons and other measures to safely control velocities and erosive forces.

***Fill Slope Roughening***

- Place fill slopes with a gradient steeper than 3:1 (H:V) in lifts not to exceed 8 inches and make sure each lift is properly compacted. Fill slopes are not as stable as cut slopes, no matter how much compaction is applied.
- Ensure that the face of the slope consists of loose, uncompacted fill 4 inches to 6 inches in depth. This is not to be confused with proper compaction necessary for slope stabilization. Use grooving or tracking to roughen the face of the slopes, if necessary.
- Apply fertilizer, mulch, or other soil amendments as necessary and as specified. Do not over fertilize. Then track or crimp. Do not blade or scrape the final slope face.

***Cut Slope Roughening***

- Create shallow grooves by normal tilling, disking, harrowing, or use a mechanical seeder. Make the final pass of any such tillage along the contour.
- Make grooves formed by such implements close together, less than 10 inches apart, and not less than 1 inch deep. Excessive roughness is undesirable where mowing is planned.

**Maintenance**

Periodically check the seeded or planted slopes for rills and washes, particularly after significant storm events greater than 0.5 inch. Fill rills and washes slightly above the original grade, then reseed and mulch as soon as possible.

Inspect monthly for the first year after construction. The slope should be inspected in early fall thereafter.

**Limitations**

- A stepped slope (or stair-step grading) is not practical for sandy soils or other soils with low cohesiveness.
- Terraced slopes and stepped slopes, as well as any slopes which are steeper than 3:1, should be designed by a licensed professional civil engineer based upon actual site conditions. Adequate drainage channels and diversions must be provided.

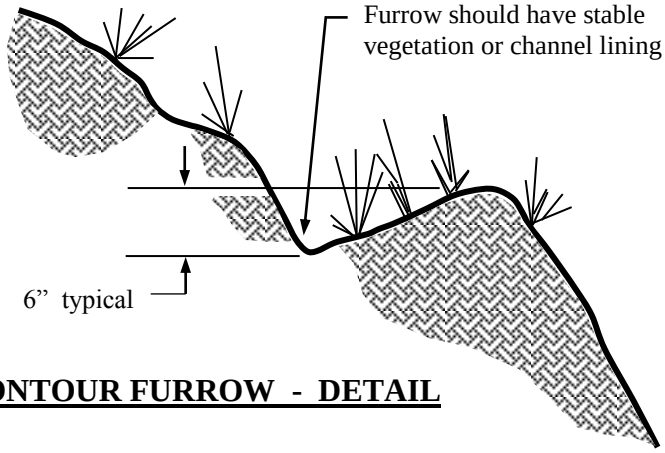
**References**

**5, 30, 31, 32, 33, 34, 35, 43, 135, 144** (see BMP Manual Chapter 10 for list)

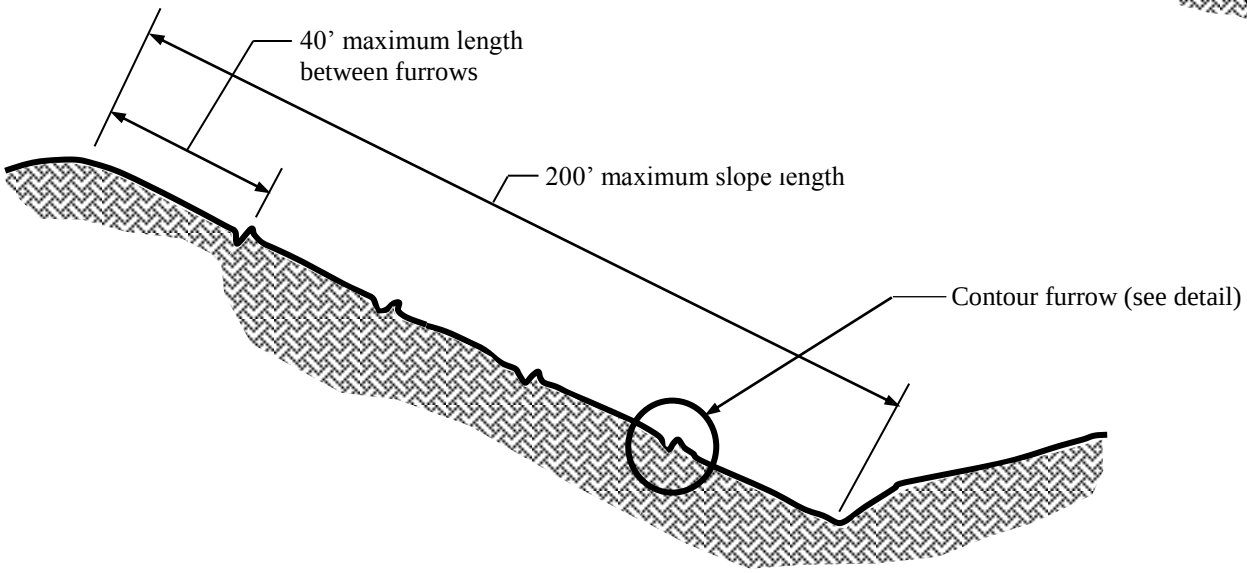
Notes:

1. Contour furrows will catch fertilizer, seed, mulch and rainfall to reduce stormwater runoff.

2. Contour furrows should be designed with appropriate channel slope to safely convey stormwater without excessive velocity.



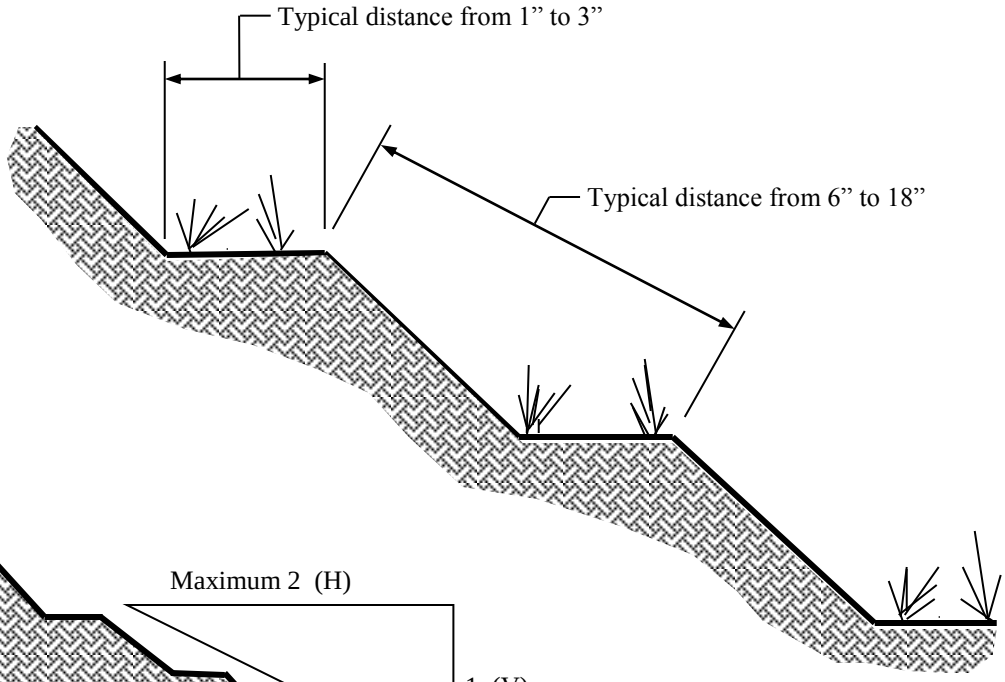

**CONTOUR FURROW - DETAIL**



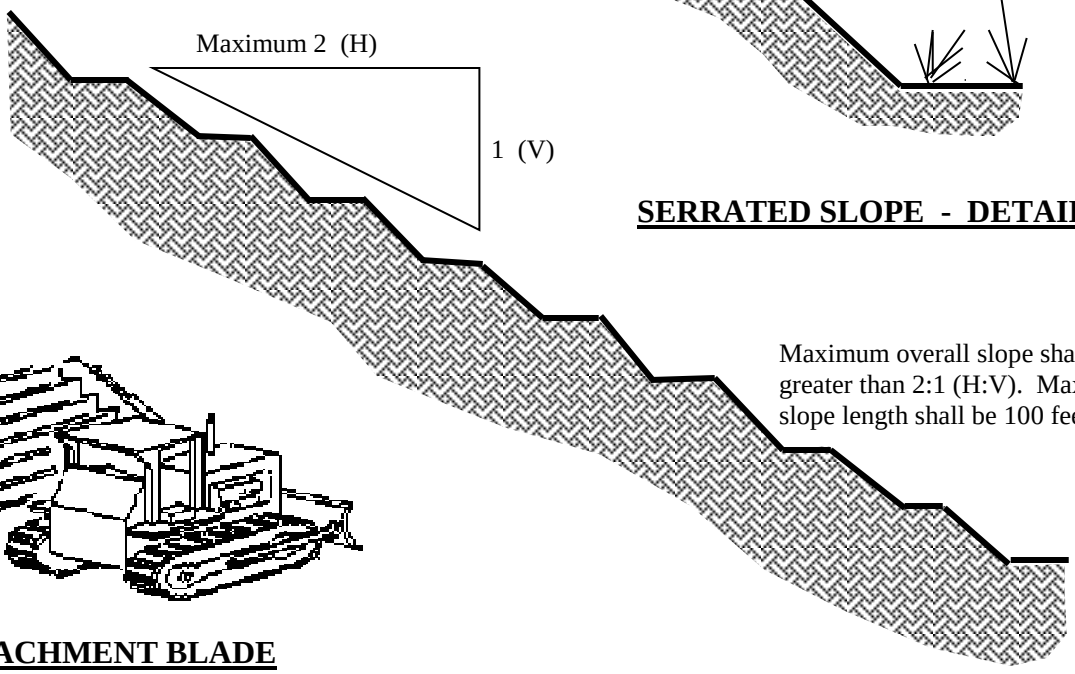

**CONTOUR FURROW - SPACING**

NOT TO SCALE

**Figure ES-04-1**
**Furrow Layout**




**SERRATED SLOPE - DETAIL**






**ATTACHMENT BLADE**

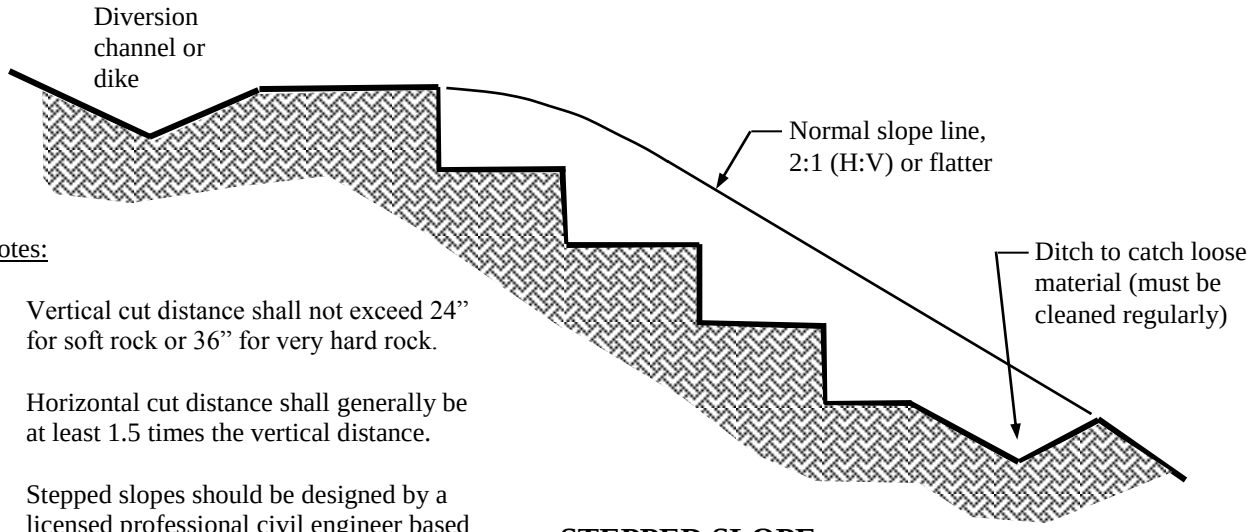
**MAXIMUM OVERALL SLOPE**

Note:

Serrated slopes will catch fertilizer, seed, mulch and rainfall to reduce stormwater runoff.

NOT TO SCALE

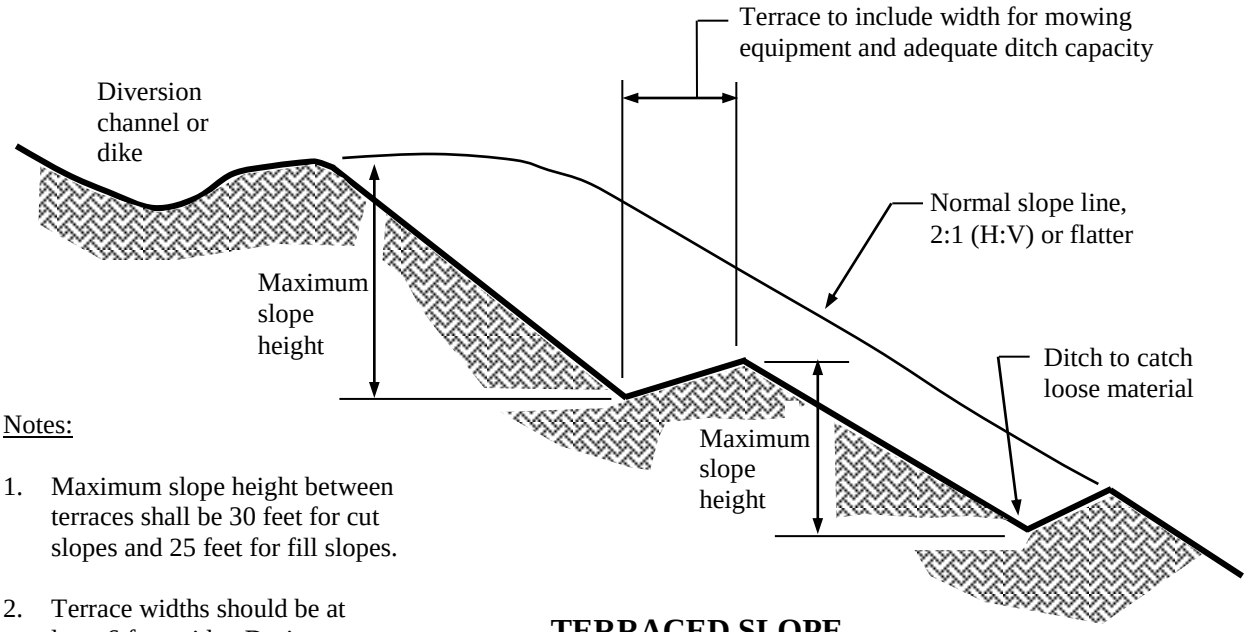
**Figure ES-04-2**
**Serrated Slope Layout**




Notes:

1. Vertical cut distance shall not exceed 24" for soft rock or 36" for very hard rock.
2. Horizontal cut distance shall generally be at least 1.5 times the vertical distance.
3. Stepped slopes should be designed by a licensed professional civil engineer based upon actual site conditions.

**STEPPED SLOPE**




Notes:

1. Maximum slope height between terraces shall be 30 feet for cut slopes and 25 feet for fill slopes.
2. Terrace widths should be at least 6 feet wide. Design terrace ditches to drain at non-erosive velocities.
3. Terraced slopes should be designed by a licensed professional civil engineer based upon actual site conditions.

**TERRACED SLOPE**

NOT TO SCALE

**Figure ES-04-3**
**Stepped Slopes and Terraced Slopes**