USDA
NATURAL RESOURCES
CONSERVATION SERVICE

MARYLAND CONSERVATION
PRACTICE STANDARD

TERRACE

CODE 600
(Reported by Ft.)

DEFINITION

An earth embankment, channel, or a combination ridge and channel constructed across the field slope.

PURPOSE

This practice may be applied as part of a conservation management system to support one or both of the following:

1. To reduce soil erosion;

2. To retain runoff for moisture conservation.

CONDITIONS WHERE PRACTICE APPLIES

This practice applies where:

1. Soil erosion by water is a problem;

2. There is a need to conserve water;

3. The soils and topography are such that terraces can be constructed and farmed with reasonable effort;

4. A suitable outlet can be provided;

5. Excess runoff is a problem.

CONSIDERATIONS

Consider equipment size and entering and exiting the field when determining terrace spacing.

Consider aligning terraces and/or installing subsurface drainage to correct wetness or seepage problems.

Consider wildlife plantings on steep back slope and narrow base terraces.

CRITERIA

General Criteria Applicable To All Purposes

Plan, design, and construct terraces to comply with all federal, state, and local laws and regulations.

Spacing - Determine the maximum spacing for terraces for erosion control by use of one of the following methods:

1. V.I. = xs + y; or H.I. = (xs + y) (100/s)

   Where:

   V.I. = vertical interval in feet (or meters)

   H.I. = horizontal interval in feet (or meters) (See Figures 1 and 2.)

   x = a variable with values from 0.4 to 0.8 (0.12 to 0.24, if metric measurements are used)

   s = land slope in percent

   y = a variable with values from 1.0 to 4.0 (0.3 to 1.2, if metric measurements are used)

   Values of x for different geographical zones are shown in Figure 4. Values of y are influenced by soil erodibility, cropping system and crop management practices. Select a value of 1.0 (0.3, for metric measurements) for erodible soils with tillage systems that provide little or no cover during periods of intense rainfall. Use a value of 4.0 (1.2, for metric measurements) for erosion- resistant soils with tillage systems that leave a large amount of cover (1.5 tons of straw equivalent per acre or 3.4 metric tons per hectare) on the surface. A value of 2.5 (0.75, for metric

measurements) shall be used if one of the factors indicated is favorable and the other unfavorable. Other values between 1.0 (0.3, for metric measurements) and 4.0 (1.2) may be used according to the estimated quality of the factors. Terrace spacing should not be less than 90 feet.

2. Revised Universal Soil Loss Equation (RUSLE)

   The spacing shall not exceed the critical slope length as determined using RUSLE. When tables are used to calculate critical slope, refer to Table 1 of this standard for terrace P factor. Soil loss in the inter-terrace interval must be less than or equal to the allowable soil loss.

   In no case shall the maximum horizontal spacing exceed that shown in Table 2 for the condition shown. The maximum limits may not be exceeded when making adjustments indicated below.

Adjust terrace spacing to fit the equipment and allow for entering and exiting the field at locations determined by the operator. Spacing may be increased as much as 10 percent to provide better alignment or location, to adjust for farm machinery, or to reach a satisfactory outlet. An additional 10% may be added for terraces with underground outlets.

When determining the terrace interval consider the likelihood of benching of steep slopes by tillage, land forming. For example, use the proposed as-built slope and length in RUSLE calculations.

For level terraces used for erosion control and water conservation, determine the spacing as previously described, but in no case shall the maximum horizontal spacing exceed 600 ft (180 m). An x value of 0.8 (0.24) may be used for all level terraces used primarily to impound water. When using the V.I. or H.I. spacing method, Figures 1 and 2 show the horizontal interval or erosion length to be used in calculating terrace spacing (Figure 3).

Figure 1

Horizontal Interval for Steep Back-Slope Terraces

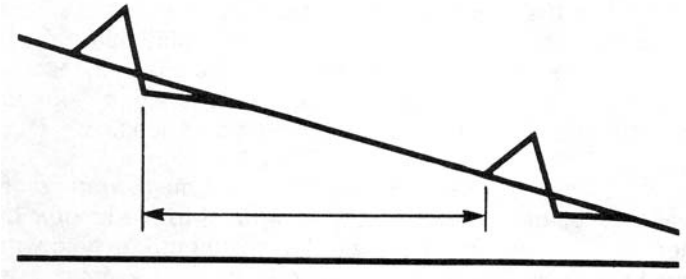

Figure 2

Horizontal Interval for Broad-Based Terraces

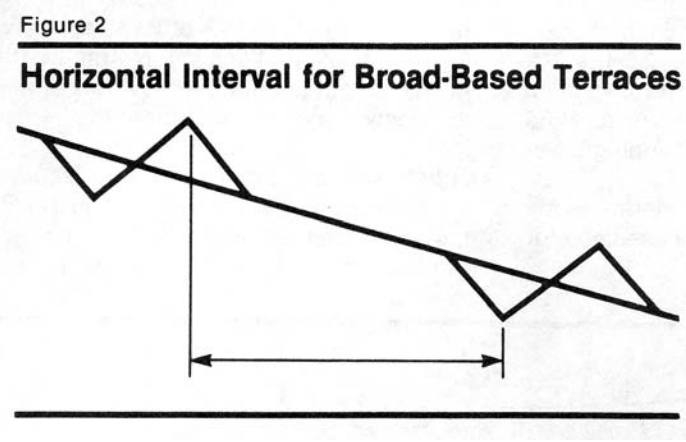

Figure 3

Terrace Spacing

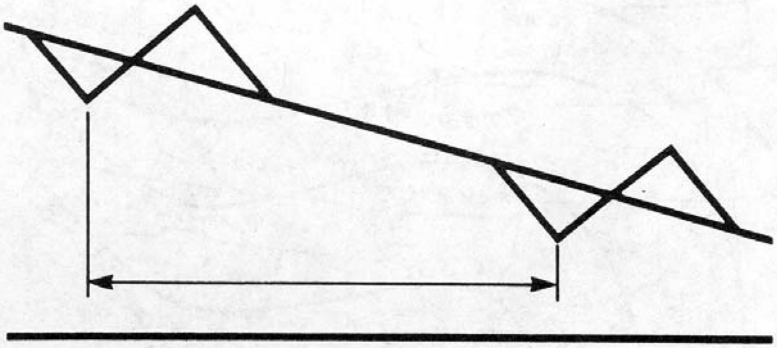

Figure 4. Values of x in equation *V.I.* = *xs* + *y;* or *H.I.* = (*xs*+*y*) (100/*s*).

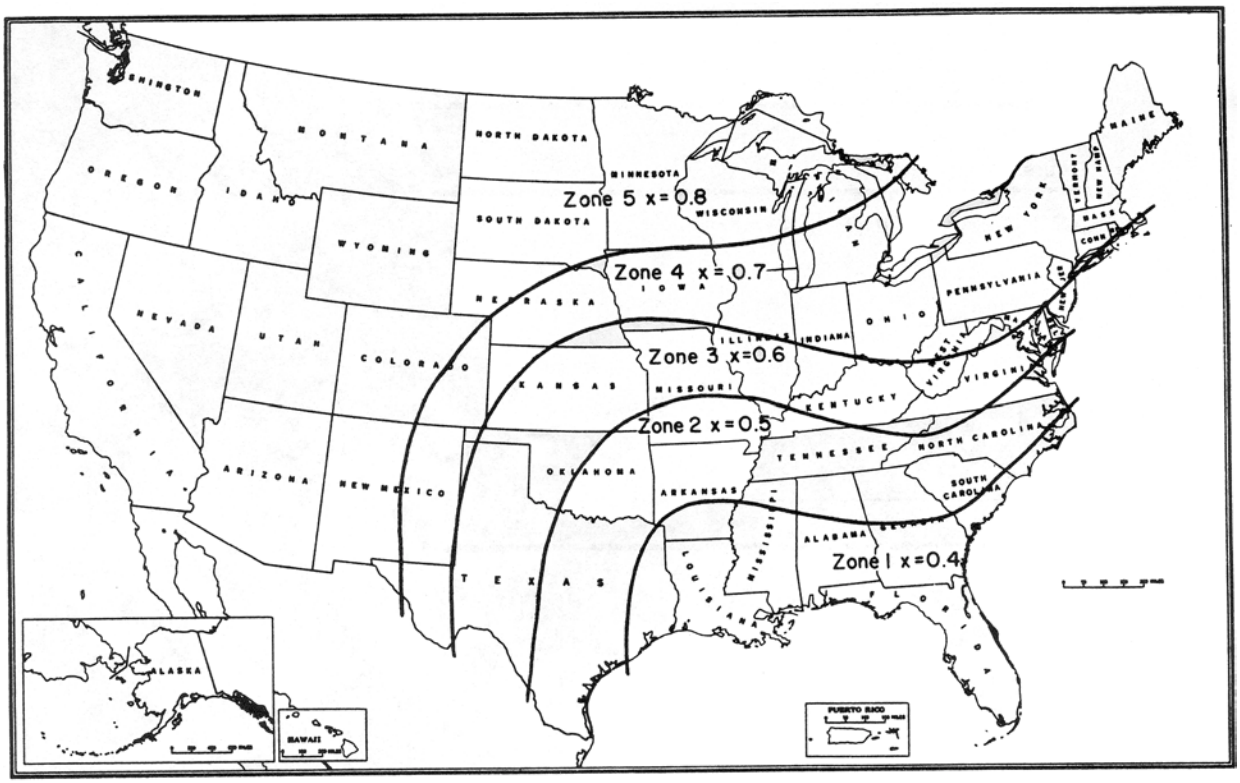

Table 1. Terrace P factors.[1]

Horizontal Interval		Closed Outlets [2]	Open Outlets with Percent Grade[3] of:		
(ft)	(m)		0.1 - 0.3	0.4 - 0.7	0.8
Less than 110	Less than 33	0.5	0.6	0.7	1.0
110-140	33-42	0.6	0.7	0.8	1.0
140-180	43-54	0.7	0.8	0.9	1.0
180-225	55-68	0.8	0.8	0.9	1.0
225-300	68-90	0.9	0.9	1.0	1.0
More than 300	More than 90	1.0	1.0	1.0	1.0

NOTE: If contouring or strip cropping P factors are appropriate, they can be multiplied by the terrace P factor for the composite P factor.

1 These figures are not appropriate for sediment yield estimates.

2 "P" factors for closed outlet terraces also apply to terraces with underground outlets and to level terraces with open outlets.

3 The channel grade is measured on the 300 ft. of terrace or the one-third of total terrace length closest to the outlet, whichever distance is less.

Table 2. Maximum horizontal spacing for terraces.

Percent Slope	RUSLE R Factor of						With Contour Stripcropping		For Concentrated Flow Control	
	0 - 35		35 - 175		> 175					
	(Ft)	(M)	(Ft)	(M)	(Ft)	(M)	(Ft)	(M)	(Ft)	(M)
<2	700	210	400	120	350	105	500	150	300	90
2-4	700	210	300	90	250	75	400	120	300	90
4-6	600	180	300	90	200	60	400	120	200	60
6-9	400	120	200	60	150	45	300	90	150	45
9-12	400	120	150	45	100	30	200	60	100	30
12-18	250	75	100	30	100	30	150	45	100	30
> 18	250	75	100	30	100	30	150	45	100	30
Minimum spacing required, all slopes	200	60	100	30	90	27	90	27	90	27

Alignment - Layout cropland terraces as parallel as practicable. Make curves long and gentle to accommodate farm machinery.

Capacity - Design the terrace to control the runoff from a 10-year frequency, 24-hour storm without overtopping. For terraces with underground outlets, increase the capacity by the estimated 10-year sediment accumulation, unless sediment is removed through maintenance and documented in the O&M Plan. Terrace systems designed to provide flood protection or to function with other structures shall have the appropriate design capacity. When the capacity is determined by the formula Q = AV and the V is calculated using Manning's formula, use a minimum "n" value of 0.035 for bare channels and 0.06 for vegetated channels. Use the appropriate NRCS Handbook or computer program to design vegetated channels.

Cross section - Proportion the terrace cross section to fit the land slope, the crops grown, and the farm machinery used. The minimum top width of the ridge is 3 feet at the design depth and 0.2 feet or 10% of the ridge height, whichever is less, is required for settlement. The steepest slope of a vegetated front or back ridge slope is 2:1. Terrace ridges, especially those with steep back slopes, can be hazardous. All cropped terrace slopes that are to be farmed shall be no steeper than those on which farm equipment can operated safely. Bring potential hazards to the attention of the responsible person and document those hazards in the O&M plan. Design the outlet of gradient and open-end level terraces so that the minimum cross section is equal to that specified for the terrace channel.

End closures - Level terraces may have open ends, partial end closures, or complete end closures. Use partial and complete end closures only on soils and slopes where the stored water will be absorbed by the soil without appreciable crop damage or where underground outlets are provided.

If terraces with closed or partly closed ends are specified, the end closures must be installed before the terraces are completed. Design the end closures so that the water flows over the end closure before overtopping the terrace ridge.

Design partial end closures not more than half the effective height of the terrace ridge. Complete end closures are more than half the height of the ridge. The cross section of the closures may be less than the terrace cross section.

Channel Grade - Determine the channel grade by one of the following methods:

1. Do not exceed the maximum channel velocities used for grassed waterways for permanently vegetated channels;

2. Design for non-erosive maximum channel velocity for cultivated channels, considering the soil and planned treatment. Compute the velocity using Manning's formula and a maximum "n" value of 0.025. Non-erosive velocities are as follows:

Soil Texture	**Maximum Flow Velocity**
Sand, Silt, Sandy Silty Loams	1.5 ft. per second
Silty or Sandy Clay Loam	2.0 ft. per second
Clay, Gravels, Silty Gravels	2.5 ft. per second

For short distances and in upper reaches, channel grades or velocities may be increased to improve alignment. If terraces have an underground outlet, water and sediment will pond in the lower reaches of the channel, thus reducing the velocity in those reaches and allowing steeper channel grades within the impoundment area. Provide minimum channel grades such that ponding in the channel caused by minor irregularities will not cause serious damage to crops or delay field operations.

Terrace Length - The volume of water stored in level terraces is proportional to the length. Therefore, it is necessary that the length be held within reason so that damage in case of a break is minimized. Level terrace length shall not exceed 3,500 ft. (1,000 m) unless the channel is blocked at intervals not exceeding 3,500 ft. (1,000 m). Normally, the capacity and the non-erosive velocity requirements will control the gradient terrace length.

Outlets **-** All terraces must have adequate outlets. Vegetated outlets may be used for gradient or open-end level terraces. Such an outlet may be a grassed waterway or other vegetated area. The outlet must convey runoff water to a point where the outflow will not cause damage. Install outlets before the terrace is constructed to provide a stable outlet. The water surface in the terrace shall not be lower than the water surface in the outlet at their junction when both are operating at design flow.

Underground outlets may be used on gradient or level terraces. The outlet consists of an intake and an underground conduit. Control the release rate with an orifice plate, increasing the outlet size, or other features or if soils and other parameters permit, design for a pressure flow system. Design the release time as to not exceed the inundation tolerance of the planned crops. The maximum drawdown times for storage terraces are: 48 hours for grass or pasture, 24 hours for row crops, and 12 hours for truck crops. Other drawdown times may be used for truck crops if requested and documented by the decision-maker. If sediment retention is desired, adjust release rate according to particle size.

Meet the requirements specified for underground outlet in the Maryland conservation practice standard for Underground Outlet (Code 620). Outlets must be installed deep enough to prevent damage from tillage equipment. The inlet shall consist of a vertical perforated pipe or other structure suitable for the intended purpose. Locate the inlet uphill of the front slope of the terrace ridge, if farmed, to permit passage of farm machinery and, if necessary, provide for the anticipated accumulation of sediment. The outlet of the conduit shall have adequate capacity for the design flow without causing erosion. Blind inlets may be used where they are effective.

Soil infiltration may be used as the outlet for level terraces. Soil infiltration must permit drainage of the design storm from the terrace channel within a reasonable period so standing water does not significantly damage crops.

Combinations of different types of outlets may be used on the same system to maximize water conservation, to affect water quality, or to provide for economical installation of a more farmable system.

Vegetation **-** Establish vegetation on all areas as soon as practicable after construction.

Drainage **-** Install subsurface drainage to reduce wetness in the terrace channel as necessary.

Criteria Applicable To Retaining Runoff For Moisture Control

Design the terrace capacity in accordance with a water budget analysis.

SPECIFICATIONS

Plans and specifications for installing terraces shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

Fill all dead furrows, ditches, or gullies prior to construction of the terrace or as part of construction. Remove all old terraces, fence rows, hedge rows, trees and other obstructions as necessary to install a farmable system.

Construct terraces to planned alignment, grade, and cross section, plus the specified overfill for settlement and that the channel will drain reasonably well.

Any ditch or depression at the bottom of the back slope should be filled and smoothed so that drainage will be away from the terrace and not parallel to it.

The materials used for the inlet and conduit will be suitable for the purpose intended. (Refer to the Maryland conservation practice standard for Underground Outlet, Code 620.) Compact terrace ridges constructed across gullies or depressions by machinery travel or other means sufficient to insure proper functioning of the terrace. Grade smooth the surface of the finished terrace to provide a professional finish.

Where it is necessary, topsoil is to be stockpiled and spread over excavations and other areas to facilitate restoration of productivity.

Carry out construction operations in such a manner that erosion and air and water pollution will be minimized.

OPERATION AND MAINTENANCE

An operation and maintenance plan shall be prepared for the operator.

The minimum requirements to be addressed in the operation and maintenance plan are:

1. Provide periodic inspections, especially immediately following runoff events;

2. Promptly repair or replace damaged components as necessary;

3. Maintain terrace ridge height and outlet elevations;

4. Remove sediment that has accumulated in the terrace to maintain capacity, a positive channel grade, and to maintain capacity where soil infiltration serves as the outlet;

5. Each inlet for underground outlets must be kept clean and sediment buildup redistributed so that the inlet is in the lowest place. Inlets damaged or cut off by farm machinery must be replaced or repaired immediately;

6. Vegetation, where specified, shall be maintained and trees and brush controlled by chemical or mechanical means;

7. Vegetated outlets should be established before construction when feasible.

8. Keep machinery away from steep back sloped terraces. Keep equipment operators informed of all potential hazards.

SUPPORTING DATA AND DOCUMENTATION

Field Data and Survey Notes

The following is a list of the minimum data needed:

1. Plan view sketch;

2. Profile and cross-section of the embankment, land slope, profile of the outlet, and other pertinent data if needed;

3. Special control or field features that must be considered in the design.

Design Data

Record on appropriate engineering paper. For guidance on the preparation of engineering plans see chapter 5 of the EFH, Part 650. The following is a list of the minimum required design data:

1. Locate practice on farm plan map in the case file;

2. Determine soil type, and any special restrictions. Provide soil loss calculations;

3. Design computations using the appropriate Engineering Field Handbook Chapter, Part 650 or by other approved method;

4. Show job class on design;

5. Design notes or design sheet must show cuts and fills, riser location (if underground outlet), required cross section, channel grades, orifice size, embankment elevation or grade rod, utility notification, construction notes, and other pertinent information;

6. Estimated quantities;

7. Details of outlet protection or other structural components needed;

8. Vegetative requirements. This must meet the criteria, specifications, and documentation requirements of the Maryland conservation practice standard for Critical Area Planting, Code 342;

9. Written Operation and Maintenance plan.

Construction Check Data/As-Built

Record on survey notepaper, SCS-ENG-28, or other appropriate engineering paper. Survey data will be plotted on plans in red. The following is a list of minimum data needed for As-builts:

1. Documentation of site visits on CPA-6. Include the date, who performed the inspection, specifics as to what was inspected, all alternatives discussed, and decisions made and by whom;

2. Record check notes during or after completion of construction showing grades and cross section of constructed components and outlets including length, width and depth;

3. Statement on seeding;

4. Final quantities and documentation for quantity changes, and materials certification;

5. Sign and date checknotes and plans by someone with appropriate approval authority. Include statement that practice meets or exceeds plans and NRCS practice Standards.

REFERENCES

1. Maryland Department of Environment, 1994 *Maryland Standard and Specifications for Soil Erosion and Sediment Contro*l;

2. Maryland Department of Transportation, State Highway Administration, *Standard Specifications for Construction and Materials*, Baltimore, Maryland, January 2001;

3. USDA, Natural Resources Conservation Service, *Maryland Field Office Technical Guide, Section IV, Standards and Specifications*;

4. USDA Natural Resources Conservation Service, *National Engineering Handbook*, Part 650, various chapters;

5. USDA Natural Resources Conservation Service, *National Handbook of Conservation Practices*.