NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

TERRACE

(Ft.)

CODE 600

DEFINITION

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

PURPOSE

This practice is applied as part of a resource management system for one or more of the following purposes:

- Reduce erosion and trap sediment
- Retain runoff for moisture conservation

CONDITIONS WHERE PRACTICE APPLIES

This practice applies where:

- Soil erosion caused by water and excessive slope length is a problem
- Excess runoff is a problem
- There is a need to conserve water
- The soils and topography are such that terraces can be constructed and reasonably farmed
- A suitable outlet can be provided

CRITERIA

General Criteria Applicable to All Purposes

Laws and Regulations. The investigation, design, and installation of the conservation practice must comply with all applicable governmental regulations, laws, permits, licenses, and registrations. The landowner is responsible for obtaining all permits and rights.

Spacing. Space terraces at intervals across the slope to achieve the intended purpose. The maximum spacing of terraces for erosion control is that necessary to achieve the soil loss tolerance (T) or other soil loss criteria that is documented in the Field Office Technical Guide. Include both the terrace system with planned as-built slopes and cultural practices such as residue management when determining soil loss. The slope length used when checking soil loss for a proposed terrace spacing is the distance from the terrace ridge to the next lower terrace channel measured along the natural flow direction. Maximum spacing for erosion control based on soil loss tolerance may be increased by as much as 10 percent to provide better location, alignment to accommodate farm machinery or to reach a satisfactory outlet. All adjustments shall be made downward from the allowable soil loss spacing.

Terrace spacing may be determined by using the Revised Universal Soil Loss Equation (RUSLE2) (or other current erosion prediction tools) or by the horizontal interval method. Refer to the Engineering Field Handbook, Chapter 8, Terraces. In no case shall the maximum horizontal spacing exceed that shown in Table 1 for the condition shown. The maximum limits may not be exceeded when making spacing adjustments.

For all methods, the steepest significant land slope within the terrace interval shall be used to determine the terrace spacing. Figures 1 and 2 show the horizontal interval or erosion length to be used in calculating terrace spacing (Figure 3). The interval from the high point of the area to be terraced to the top terrace may be up to one and one-half times the normal interval. The horizontal spacing does not have to be less than 90 feet.

Table 1				
Slope	RUSLE, R factor of: 0-35	35-175	With contour strip-cropping	Concen-trated Flow Control
%	(Ft)	(Ft)	(Ft)	(Ft)
0 - 2	700	500	600	700
2 -4	700	400	600	700
4 - 6	600	400	600	600
6 - 9	400	300	400	500
9 -12	400	250	250	500
12-18	250	200	150	400
> 18	250	200	150	300

RUSLE2. The spacing must be equal to or less than the maximum slope length that will keep soil loss within allowable limits as determined by RUSLE2. The spacing shall be based upon the most intensive use planned.

Horizontal Interval Method. The maximum spacing for terraces for erosion control shall be determined by:

H.I. = (xs + y) (100/s)

Where:

H.I. = horizontal interval in feet

(See Figures 2 and 3)

x = a variable with values from 0.4 to 0.8

s = land slope in percent

y = a variable with values from 1.0 to 4.0

Value of x for South Dakota (SD) is 0.8.

Values of y are influenced by soil erodibility, cropping system, and crojp management practices. A value of 1.0 shall be selected for erodible soils with tillage systems that provide little or no cover during periods of intense rainfall. A value of 4.0 shall be used for erosion resistant soils with tillage systems that leave a large amount of cover (1.5 tons of straw equivalent per acre on the surface). A value of 2.5 shall be used if one of the factors indicated is favorable and the other unfavorable. Other values between 1.0 and 4.0 may be used according to the estimated quality of the factors.

Table 2 shows typical Y values. Table 3 shows maximum terrace spacing for soil erodibility factors of 0.28-0.64 and typical management systems in eastern South Dakota (SD). Spacings for other soils or management systems must be determined on a case-by-case basis.

Table 2			
Y			
Ground Cover	Soil Erodibility Factor (K)		
	0-0.20	0.20-0.28	0.28-0.64
10%	2.5	1.75	1.0
40%	3.25	2.5	1.75
80%	4.0	3.25	2.5

Table 3			
Terrace Spacing for K factor 0.28-0.64 (ft)			
Field Slope	Ground Cover		
	10%	40%	80%
0-2%	140	170	210
3-4%	110	130	150
5-6%	100	110	125
7-8%	95	105	115
9-10%	90	100	105
11-13%	90	95	100
>13%	90	90	90

Alignment. To accommodate farm machinery and farming operations, cropland terraces shall be parallel with long gentle curves, where feasible. When multiple terraces are used in a field, design the terraces to be as parallel to one another as practicable.

Capacity. Design terraces to have enough capacity to control the runoff from a 10-year frequency, 24-hour storm without overtopping. For terrace systems designed to control excess runoff or to function with other structures, choose a larger design storm that is appropriate to the risk associated with the installation.

For terraces with underground outlets, the capacity to contain the design storm can be a combination of storage and outflow through the underground outlet. For terraces that store runoff (storage or level terraces), increase the storage capacity by the estimated 10-year sediment accumulation, unless the Operation and Maintenance Plan specifically addresses the periodic removal of sediment.

For terraces with open outlets, base the terrace channel size on the capacity using the densest and longest vegetation. Base the capacity of the channel on a bare earth channel for cropped fields or in the case of a permanently vegetated channel, the appropriate vegetation. For bare earth channels use a Manning's n value of 0.035 or greater to calculate capacity. For permanently vegetated channels, refer to Conservation Practice Standard (412), Grassed Waterway for design criteria to determine capacity.

Terrace cross section. Proportion the terrace cross section to fit the land slope, the crops grown, and the farm machinery used. Avoid the use of terrace cross-sections that result in disturbance of all of the soil in the spacing between terraces. Add ridge height if necessary to provide for settlement, channel sediment deposits, ridge erosion, the effect of normal tillage operations, or safety. At the design elevation, the ridge must have a minimum width of 3 ft. For terraces with open outlets, design the capacity of the outlet to be equal to or greater than the capacity of the terrace channel.

Design all farmable terrace slopes no steeper than 5:1 in order to allow safe operation of farming equipment. For non-farmable terrace slopes, the steepest slopes allowable are 2 horizontal to 1 vertical unless an analysis of site-specific soil conditions indicate that steeper slopes will be stable.

Topsoiling. Salvage topsoil from the footprint of the construction area of the terrace to spread over the excavated slopes and terrace ridges to facilitate restoration of the field unless the excavated slope or ridge surface is of similar texture as the available topsoil.

Channel grade. Design the terrace channel to be stable with non-erosive velocities but with sufficient grade to prevent damage to crops or to prevent delay of farming activities from prolonged ponding.

For cultivated terraces, base the channel stability on a bare earth condition using a maximum Manning's n value of 0.035. For permanently vegetated channels, base the channel stability on the appropriate vegetation. Refer to Conservation Practice Standard 412, Grassed Waterway and Engineering Field Handbook, Part 650, Chapter 7 for design criteria and procedures to determine stability for both bare and vegetated conditions.

In the upper reaches of a channel, grades may be increased to improve alignment. For terraces with an underground outlet, channel grades can be steeper within the impoundment area.

Level terraces. The volume of water stored in level terraces is proportional to the length. To reduce the potential risk from failure, do not design level terraces with lengths that exceed 3,500 feet unless the channel is blocked at intervals not exceeding 3,500 feet. Level terraces can have either full or partial end closures or be open-end. If a partial end closure is used, areas downstream from the end closure must be protected from flow that will exit from the closure before the design storm is reached.

Outlets. All terraces must have adequate outlets. The outlet must convey runoff water to a point where it will not cause damage.

Vegetated outlets are suitable for gradient or open-end level terraces. Grassed waterways or naturally vegetated drainage ways may be used as a vegetated outlet. Install and stabilize grassed waterways prior to the construction of the terrace so that the terrace will have a stable outlet when it is constructed. The capacity of the vegetated outlet must be large enough so that the water surface in the outlet is at or below the water surface in the terrace at the design flow.

Underground outlets are suitable for use on all terrace types. The outlet consists of an intake and an underground conduit. If underground outlets are required, use Conservation Practice Standard, 620, Underground Outlet.

Underground outlets may be designed for either pressure or gravity flow. If a pressure system is designed, all pipes and joints must be adequate to withstand the design pressure, including surges and vacuum. For gravity flow systems, use a flow-restricting device such as an orifice or weir to limit flow into the conduit or choose conduit sizes that are large enough to prevent pressure flow.

Design the outlet so that the flow release time does not exceed the inundation tolerance of the planned crop. If sediment retention is a primary design goal, adjust the release rate according to sediment particle size. Locate the intake structure for the underground outlet to accommodate farming operations and to allow for sediment accumulation.

Conduits 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. The inlet shall be located 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 rates, under average rainfall conditions, must permit infiltration of the design storm from the terrace channel within the inundation tolerance of the planned crops.

Combinations of different outlet types may be used on the same terrace system to optimize water conservation, improve water quality, and to accommodate farming operations or to provide for economical installation.

Vegetation. Stabilize all areas planned for vegetation as soon as possible after construction. Refer to Conservation Practice Standard, 342, Critical Area Planting or state planting guide for seeding criteria and as needed, use the criteria in Conservation Practice Standard, 484, Mulching.

Additional Criteria Applicable to Retaining Runoff for Moisture Conservation

For terraces installed to conserve moisture, perform a water budget analysis to determine the volume of water that must be collected to meet the requirements of the water budget. As a minimum the terrace must still meet the design storm and sediment volume requirements in the **Capacity** section of this standard.

CONSIDERATIONS

One of the keys to a successful terrace system is to make sure that the terrace layout fits the farm equipment. This includes making curves long and gentle and spacing terraces so that the operator can make an even number of trips between terraces.

Terrace ridges and cut slopes can introduce steep and potentially hazardous slopes into a crop field. Where slopes will be farmed, make sure they can be safely negotiated with the operator's equipment. Where steep slopes are unavoidable make sure the operator is aware of the location and potential danger of the slopes.

The soil survey can be a valuable resource when planning and designing terrace systems. The soil survey can identify potential problems such as the presence of layers in the soil profile that will limit plant growth. Field investigations can then identify problem areas to avoid such as shallow bedrock or dense, acid or saline layers that will adversely affect plant growth if construction brings them into the root zone.

Steep sided terraces that are in permanent vegetation can provide significant areas of habitat for wildlife. Consider planting native species that provide food and cover for wildlife. Do not mow these areas until after the nesting season to improve wildlife production.

Hillside seeps in a crop field can cause cropping problems. Consider aligning terraces and/or installing subsurface drainage to intercept and correct seepage problems. Install the drainage prior to terrace construction by using Conservation Practice Standard 606, Subsurface Drain.

Erosion can be a problem at the outfall of an underground outlet. To ensure an adequate outlet, protect the outfall of the underground outlet so that it is stable.

Outlets from terraces might provide a direct conduit to receiving waters for contaminated runoff from cropland. Terraces should be installed as part of a conservation system that addresses issues such as nutrient and pest management, residue management and filter areas.

Intakes for underground outlets can be easily damaged during cultivation, planting and harvesting operations. Using brightly colored inlets, barriers around the inlet or otherwise clearly marking the inlet will help prevent damage.

PLANS AND SPECIFICATIONS

Prepare plans and specifications for terraces that describe the requirements for applying the practice according to this standard. As a minimum the plans and specifications must include:

- A plan view of the layout of the terrace system.
- Typical cross sections of the terrace(s).
- Profile(s) or planned grade of the terrace(s).
- Details of the outlet system
- If underground outlets are used, details of the inlet and profile(s) of the underground outlet.
- Seeding requirements if needed.
- Quantity of materials needed for the construction.
- Site specific construction specifications that describe the installation of the terrace system.

OPERATION AND MAINTENANCE

Prepare an operation and maintenance plan for the operatorto follow for the design life of the terrace system. The minimum requirements to be addressed in the written operation and maintenance plan are:

- Periodic inspections, especially immediately following significant runoff events.
- Prompt repair or replacement of damaged components.
- Maintenance of terrace ridge height, channel profile, terrace cross-sections and outlet elevations.
- Removal of sediment that has accumulated in the terrace channel to maintain capacity and grade.
- Regular cleaning of inlets for underground outlets. Repair or replacement of inlets damaged by farm equipment. Removal of sediment around inlets to ensure that the inlet remains the lowest spot in the terrace channel.
- Where vegetation is specified, complete seasonal mowing, control of trees and brush, reseeding and fertilizing as needed.
- Notification of hazards about steep slopes on the terrace.

REFERENCES

USDA, NRCS. 2004. Revised Universal Soil Loss Equation, Ver. 2 (RUSLE2).

USDA, NRCS. National Engineering Handbook, Part 650, Engineering Field Handbook, Chapter 7, Grassed Waterways

USDA, NRCS. National Engineering Handbook, Part 650, Engineering Field Handbook, Chapter 8, Terraces

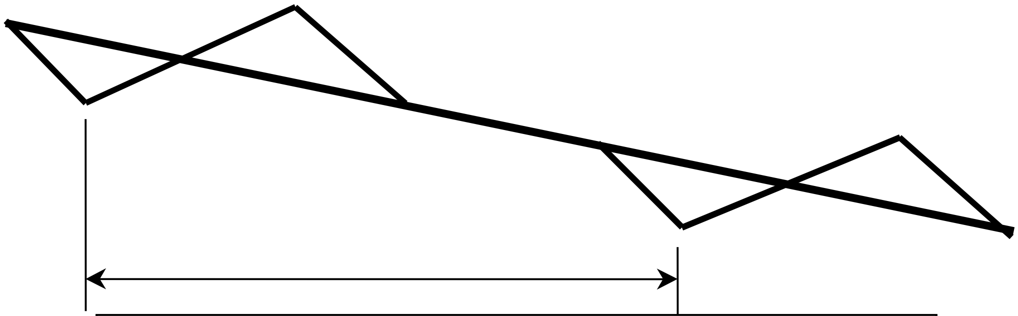

Figure 1. Horizontal Interval for Broad-Base Terraces

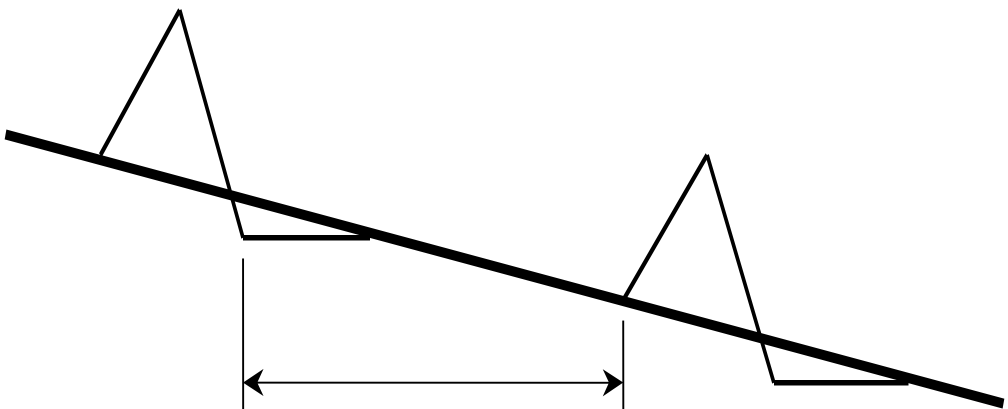

Figure 2. Horizontal Interval for Steep Back-Slope Terrace

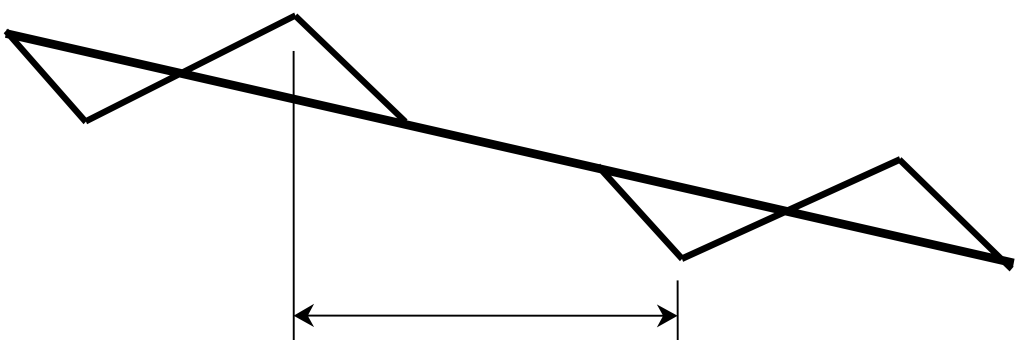

Figure 3. Terrace Spacing