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 by reducing slope length;

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 farmed with reasonable effort;

A suitable outlet can be provided.

CRITERIA

General Criteria Applicable To All Purposes

Terraces shall be planned, designed, and constructed to comply with all federal, state, and local laws and regulations.

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 soil loss tolerance (T). 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 adjusted to provide better 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

Percent	(Ft.)	(Ft.)	(Ft.)	(Ft.)
0 - 2 2 -4 4 - 6	700 700 600	500 400 400	600 600 600	700 700 600
6 - 9 9 -12 12-18	400 400 250	300 250 200	400 250 150	500 500 400
> 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 crop 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 SD. Spacings for other soils or management systems must be determined on a case-by-case basis.

For level terraces used for erosion control and water conservation, the spacing shall be determined as previously described, but in no case shall the maximum horizontal spacing exceed 600 ft.

Table 2

Y

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

Table 3

Terrace Spacing for K factor 0.28-0.64 (ft)

Field Slope	Ground Cover		
	10%	40%	80%
0-2% 3-4% 5-6%	140 110 100	170 130 110	210 150 125
7-8% 9-10% 11-13%	95 90 90	105 100 95	115 105 100
>13%	90	90	90

Alignment. Cropland terraces shall be parallel if feasible to accommodate farm machinery and farming operations. Design cropland terraces with long, gentle curves. 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 terraces with underground outlets, the capacity to contain the design storm can be a combination of storage and outflow through the underground outlet. The storage capacity of terraces shall be increased by the estimated 10-year sediment accumulation, unless the Operation and Maintenance (O&M) Plan specifically addresses the annual removal of sediment. 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 open outlets, the capacity is based on the terrace channel size and stability. Base the capacity of the channel on a bare earth channel for crop 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 (CPS) Grassed Waterway (412) for design criteria to determine capacity.

Design level terraces to contain the runoff from a 10-year 24-hour rainfall event, and the expected 10-year sediment accumulation, unless the O&M Plan specifically addresses the annual removal of sediment.

Terrace cross section. Proportion the terrace cross section to fit the land slope, the crops grown, and the farm machinery used. Add ridge height if necessary to provide for settlement, channel sediment deposits, ridge erosion, the effect of normal tillage operations, or safety. The ridge shall have a minimum width of three feet at the design elevation. For terraces with open outlets, design the capacity of the outlet to be equal to or greater than the capacity of the terrace channel.

All farmable terrace slopes shall be no steeper than those on which farm equipment can operate safely. For nonfarmable terrace slopes, the steepest slopes allowable are two horizontal to one vertical unless an analysis of site specific soil conditions indicate that steeper slopes will be stable.

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 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, install the end closures before the terraces are completed. End closures less than or equal to half the effective height of the terrace ridge are considered partial closures while those greater than half the height are considered complete closures. For level terraces that have end closures that are lower than the terrace ridge elevation, areas downstream from the end closure must be protected from flow that will exit from the closure before the design storm is reached.

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. The maximum velocity for erosion-resistant soils (clay textural classification) is 2.5 ft./s.; for average soils (silt textural classification), 2.0 ft./s.; and for easily erodible soils (sand textural classification), 1.5 ft/s. Use Manning's equation to compute velocity, with a maximum n value of 0.035 to evaluate velocity for channel stability.

For permanently vegetated channels, base the channel stability on the appropriate vegetation. Refer to CPS Grassed Waterway (412) for design criteria to determine stability.

For short distances 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 for short distances within the impoundment area.

Level terrace length. 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.

Outlets. All terraces must have adequate stable 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 below the water surface in the terrace at the design flow.

Underground outlets may be used on gradient or level terraces. The outlet consists of an intake and an underground conduit. Refer to CPS Underground Outlet (620) or Subsurface Drains (606) for design criteria for the underground outlet.

An orifice plate, an increase in conduit size, or other features shall be installed as needed to control the release rate, prevent reverse flows at lower inlets, and prevent excessive pressure in the conduit. Terraces shall be designed to control a 10-year frequency, 24-hour storm without overtopping. The release time shall not exceed the inundation tolerance of the planned crops. If sediment retention is desired, adjust release rate according to the sediment particle size.

Locate the inlet 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, accommodate farming operations, or to provide for an economical installation.

Vegetation. Stabilize all areas planned for vegetation as soon as possible after construction. Refer to CPS Critical Area Planting (342) for seeding criteria.

Drainage. Install subsurface drainage to stabilize soils and improve terrace function as necessary. Refer to CPS Subsurface Drain (606) for design and installation criteria.

Additional Criteria Applicable to Retaining Runoff for Moisture Control

For terraces installed to retain moisture, perform a water budget analysis to determine the volume of water that must be collected to meet the requirements of the water budget. Consider the effects of snowcatch and melt on water budget components. 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 limiting layers to plant growth in the soil profile. 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.

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 can 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.

Inlets 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.

For terraces that will be farmed or otherwise revegetated, the stripping and stockpiling of topsoil from the construction area prior to excavation and then spreading the topsoil on the completed terrace will improve the growth of vegetation after construction.

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 shall 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.

Site specific construction specifications that describe the installation of the terrace system.

OPERATION AND MAINTENANCE

Prepare an O&M plan for the operator. The minimum requirements to be addressed in a written O&M 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, seasonal mowing, and control of trees and brush.

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 8.

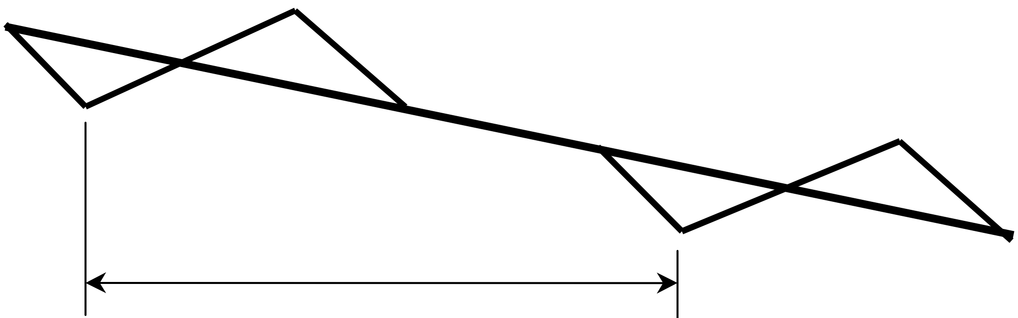

Figure 1. Horizontal Interval for Broad-Base Terraces

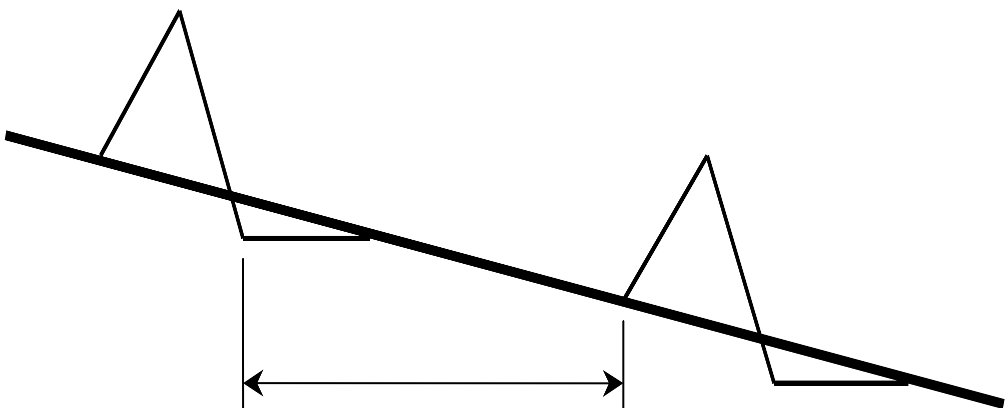

Figure 2. Horizontal Interval for Steep Back-Slope Terrace

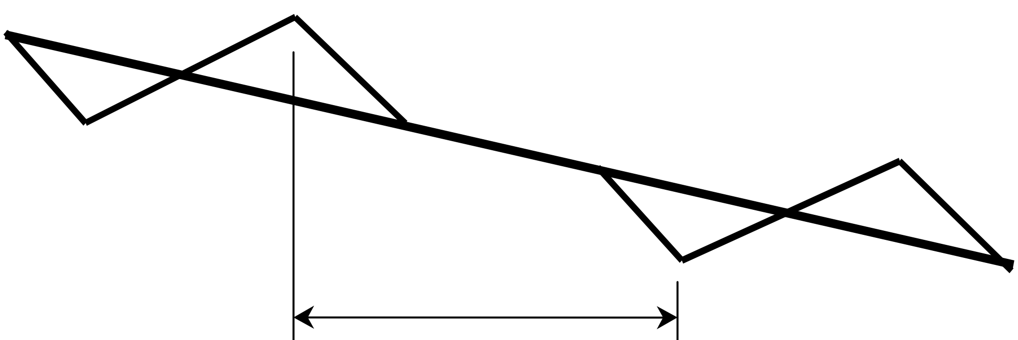

Figure 3. Terrace Spacing