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 may be 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

For treatment of sheet and rill erosion where the soil loss is within the allowable tolerance, ephemeral gully erosion, or other concentrated flow erosion, diversions must be designed using criteria in Oklahoma NRCS Conservation Practice Standard (CPS), *Diversion (362)*, instead of terraces.

CRITERIA

General Criteria Applicable To All Purposes

Spacing. Spacing for terraces as set forth in this standard is for the control of sheet and rill erosion that exceed the allowable soil loss tolerance (T) or other soil loss criteria that is documented in the Field Office Technical Guide. Refer to the current NRCS accepted erosion prediction software and user guide to determine soil loss.

The maximum spacing for terraces shall be determined by the following formula:

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

Where:

V.I. = vertical interval in feet

H.I. = horizontal interval in feet

(See figure 1 and 2)

x = 0.6 for areas of the state west of I-35;

0.5 for areas of the state east of I-35.

0.8 for level terraces that impound water

s = land slope in percent

y = a variable with values from 1.0 to 4.0

Values of y are influenced by soil erodibility, cropping system and crop management practices. Values for y are given in Table 1.

Table 1. Values for "y"

	y Values	
CP_f *	T/K $\geq$ 15.2	T/K < 15.2
< 0.22	4.0	3.5
0.22 – 0.35	3.5	3.0
0.36 – 0.43	3.0	2.0
> 0.43	2.0	1.0

* CP_f is calculated from the RUSLE2 Net C factor (C) times P_f. P_f is the Net Contour factor (Pc) times the Net Ridge factor (Pr).

$$CP_f = C \times Pc \times Pr$$

Table 2. Maximum horizontal interval for terraces

	RUSLE2 R Factor of			With Contour Stripcropping
	0 - 35	35 – 175	> 175	
Percent Slope	Ft	Ft	Ft	Ft
0 - 2	700	500	450	600
2.1 - 4	700	400	300	600
4.1 - 6	600	400	200	600
6.1 - 9	400	300	150	400
9.1 - 12	400	250	150	250
12.1 - 18	250	200	150	150
> 18	250	200	150	150

The average horizontal interval does not have to be less than 100 feet.

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

Spacing may be increased as much as 10 percent to provide better location or alignment, to adjust for farm machinery, or to reach a satisfactory outlet, if the additional distance between terraces does not exceed the values in Table 2.

The likelihood of benching of steep slopes by tillage, land forming, and erosion shall be considered when determining the terrace interval.

When estimating sheet and rill erosion for terraces spaced using the V.I. or H.I. spacing method, Figures 1 and 2 show the erosive slope length to be used. Figure 3 represents actual terrace spacing.

Alignment. Cropland terraces shall be parallel if feasible and as parallel as practical. To accommodate farm machinery and farming operations, design cropland terraces with long gentle curves, where feasible. Terraces shall be aligned such that water is not diverted from one watershed to another, unless proper permits are obtained.

Cross section. Dimensions for field terraces are given in Table 3. 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, and safety. Ridge heights beyond that given in Table 3 shall require 0.3 feet freeboard plus 10% of ridge height for settlement. At the design elevation, the ridge must have a minimum width of 4 feet.

Design the front and back slopes of the terrace to be approximately the same, except when a grass back slope is used. The steepest slope of a vegetated front or back ridge slope is 2 horizontal: 1 vertical. Terrace ridges, especially those with steep back slopes, can be very hazardous. Design all cropped terrace slopes that are to be farmed no steeper than 5 horizontal: 1 vertical. Potential hazards must be brought to the attention of the responsible person.

For terraces with open outlets (gradient and open-end level terraces), design the capacity of the outlet to be equal to or greater than the capacity of the terrace channel.

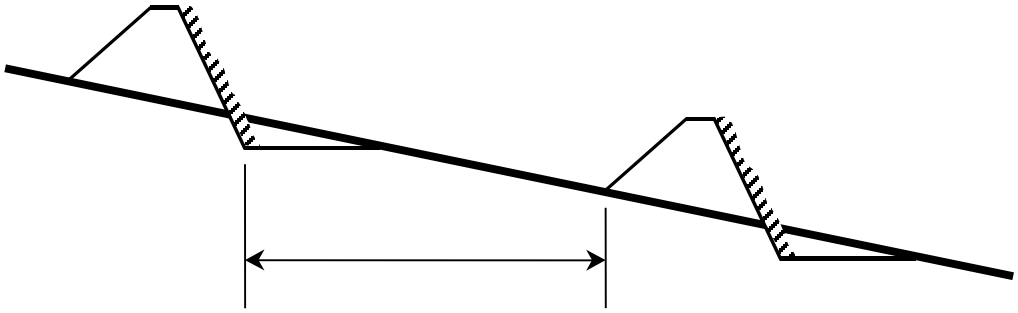

Figure 1. Erosive Slope Length for Steep Back-slope Terraces

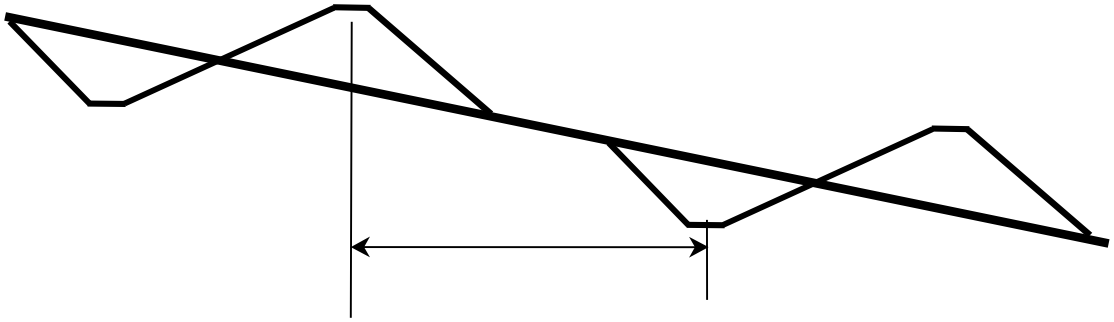

Figure 2. Erosive Slope Length for Broad-Based Terraces

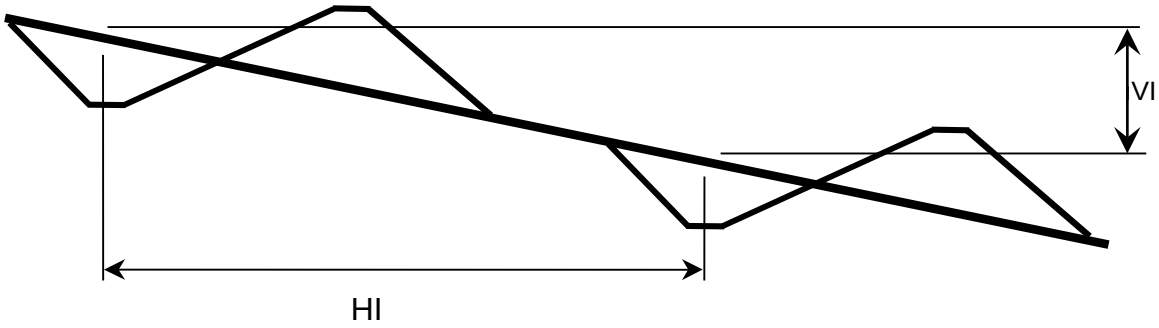

Figure 3. Terrace Spacing

Table 3 - Dimensions for Field Terraces

Percent Slope	Height above Channel Ft.	Channel Bottom Width Ft.	Cross Section Area of Channel $Ft.^2$	Width* Standard Ft.	Width* Broadbase Ft.
4% or less	1.2	8	20	22	30
4.1 to 8	1.4	8	20	20	28
8.1 to 10	1.0	4	10	20	28
10.1 to 12	1.0	4	10	20**	28

* Width is measured from the intersection of the toe and the channel on the front slope to the intersection of the toe and natural ground on the back slope.

** Use permanently vegetated grass back slope and top for terrace ridge. Back slope would be 3:1 or steeper.

Note: For terraces with $\leq$ 0.1' grade per 100 ft and for terraces with end closures, add 0.2 ft. to height above channel for freeboard.

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 out flow 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 terrace systems designed to provide flood protection, 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, 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 crop fields or in the case of a permanently vegetated channel, the appropriate vegetation. In place of Table 3, the capacity for an individually designed terrace with a bare soil channel shall be calculated using a Manning's "n" value of 0.06 or greater and the additional depth for freeboard and overfill for settlement shall be waived. For permanently vegetated channels refer to Oklahoma NRCS CPS, *Grassed Waterway (412)* for design criteria to determine capacity.

Channel grade. When making an individual terrace design, channel grade shall be determined by one of the following methods:

1. For permanently vegetated channels, base the channel stability on the appropriate vegetation. Refer to Oklahoma NRCS CPS, *Grassed Waterway (412)* and Engineering Field Handbook, Part 650, Chapter 7 for design criteria and procedures to determine stability for both bare and vegetated conditions.

2. For cultivated channels, the maximum channel velocity shall be non-erosive for the soil and planned treatment. Maximum design velocities or channel grades are:

- 2.5 ft/s or a channel grade of 0.5 percent for erosion-resistant soils (c, sic, sc, cl);
- 2.0 ft/s or a channel grade of 0.4 percent for erodible soils (l, sil, sicl, scl); and
- 1.5 ft/s or a channel grade of 0.2 percent for easily erodible soils (sl, fsl, vfsl).

Velocity shall be computed by Manning's formula, using a maximum n value of 0.035 to determine velocity for channel stability.

Channel grades may be uniform or variable. For short distances and in upper reaches, channel grades or velocities may be increased to improve alignment. If a terrace is designed utilizing Table 3, in no case shall the designed grade exceed the length and grade requirements listed in the Terrace Length section of this standard. 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. As a result, channel grades for terraces with underground outlets are allowed to be steeper for short distances within the impoundment area.

Minimum grades shall be such that ponding in the channel caused by minor irregularities will not cause serious damage to crops or delay field operations.

Freeboard. The Height above Channel values found in Table 3 include freeboard. No additional freeboard is needed except as noted in Table 3 for terraces with very flat or level grades and for terraces with end closures. In place of Table 3, individually designed terraces shall include no less than 0.3 feet of freeboard, unless otherwise specified in this standard.

End closures. If terraces with closed or partly closed ends are specified, the end closures must be installed before the terraces are completed. The end closures shall be designed so that the water flows over the uphill side of the end closure (away from the terrace ridge) before overtopping the terrace ridge.

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. The base width of the end closures and blocks shall be equal to that of the terrace.

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. For gradient terraces, the capacity and the non-erosive velocity requirements will normally control length. Maximum length for gradient terraces shall be governed by the following:

- 2500 feet for terrace grades of $\leq$ 0.1%,
- 3000 feet for grades > 0.1% and $\leq$ 0.3%,
- 2000 feet for terrace grades of 0.4%
- 1000 feet for terrace grades of 0.5%

If lengths longer than those specified above are needed for a gradient terrace, an individual design is required.

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

Vegetated outlets may be used for gradient or open-end level terraces. Such an outlet may be a grassed waterway or other vegetated area. Outlets shall be installed and vegetation established 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. If underground outlets are required use Oklahoma NRCS CPS, *Underground Outlet (620)*.

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 plate or weir to limit flow into the conduit or choose conduit sizes that are large enough to control the release rate and prevent pressure flow.

Design the outlet so that the release time does not exceed 48 hours for the design storm. Shorter periods may be necessary for some crops depending on soil characteristics and water tolerance of crops being grown. If sediment retention is desired, adjust release rate according to particle size.

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.

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

Upper terraces in a system, especially level terraces or those with complete or partial end closures, shall not discharge into lower terraces unless the lower terrace is designed to handle the additional water.

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.

Vegetation. Stabilize all areas planned for vegetation as soon as possible after construction. Refer to Oklahoma NRCS CPS, *Critical Area Planting (342)* and/ or *Oklahoma Plant Materials Technical Note 21* for seeding criteria and as needed, use the criteria in Oklahoma NRCS CPS, *Mulching (484)*.

Additional Criteria Applicable To Retaining Runoff For Moisture Control

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 General Criteria for Capacity section of this standard.

Additional Criteria Applicable to Level Terraces

Level terraces are applicable only on land slopes of 8% or less.

Spacing. 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 interval exceed 600 ft. The average horizontal interval does not have to be less than 100 feet; however, if spacing formulas indicate a horizontal interval less than 100 feet and a 100 foot spacing is used, the capacity shall be checked. The height shall be set at either that specified in Table 3 or that needed for capacity for an individually designed terrace, whichever is greater.

Capacity. Design level terraces to contain the runoff from a 10-year 24-hour rainfall event, and the expected 10-year sediment accumulation, unless sediment is removed annually through maintenance.

Terrace Length. Level terrace length shall not exceed 3,500 ft. unless the channel is blocked at intervals not exceeding 3,500 ft.

End closures. Level terraces may have open ends, partial end closures, or complete end closures. Partial and complete end closures shall be used 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.

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.

Outlets. 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.

Additional Criteria Applicable To Individual Terrace Designs

When terraces are spaced with an individual terrace design, sheet and rill erosion rates shall be analyzed. If sheet and rill erosion are not a concern, Oklahoma NRCS CPS, *Diversion (362)* shall be used.

Additional Criteria Applicable To Evaluating Existing Terraces

Existing terraces may need to be evaluated for two reasons: 1) Adding new terraces below the existing terraces, and/or 2) Justifying the need to rebuild.

Adding Terraces Below Existing Terraces. When adding new terraces below existing terraces, a visual inspection is needed to assure that the terraces are functioning properly and do not have any ridge breaks or channel blocks. At least one cross section shall be taken at a point that appears to be the weakest in the terrace system. This cross section must meet the criteria outlined in Table 4 in order to construct new terraces below the existing ones.

Table 4. Existing Terrace Evaluation

Ht. Above Channel (Ft)	Channel Cross Sectional Area (Ft^2)
0.7	20
0.8	18
0.9	17
1.0	16

An alternative evaluation would be to show by individual terrace design that the existing terraces meet the channel capacity and grade requirements of this standard.

Justifying the Need to Rebuild Terraces. Terrace reconstruction is warranted only if the terraces meet current spacing and channel grade criteria and have a stable outlet. Terraces meeting any of the following should be considered for rebuilding:

- Terrace has numerous breaches,
- Ht. Above Channel is < 0.7 feet,
- Channel Cross Sectional Area is < 50% of design.

Each terrace in a system must be evaluated. Terraces not meeting the above criteria are considered adequate and would not need to be rebuilt.

Existing terraces shall not be removed prior to rebuilding. Rebuilt terraces shall meet all criteria for a new terrace.

Isolated low points in the terrace profile should be repaired through normal operation and maintenance.

Removing Old Terraces

Criteria for terrace removal are found in Oklahoma NRCS CPS, *Land Smoothing (466)*.

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 so that they end up on the same side of the field they started on.

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. Install the drainage prior to terrace construction by using Oklahoma NRCS CPS, *Subsurface Drain (606)*.

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 crop land. 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.

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 in writing the installation of the terrace system.

OPERATION AND MAINTENANCE

Preparer a written operation and maintenance plan for the operator to follow for the design life of the terrace system. The minimum requirements to be addressed in the operation and maintenance plan are:

- Perform periodic inspections, especially immediately following runoff events.
- Promptly repair or replace damaged components as necessary.
- Maintain terrace ridge height, channel profile, terrace cross-sections and outlet elevations.
- Perform tillage operations as close to the contour of the terrace channel as is practical. Tillage operations which cross over the terrace ridge may reduce the height of the terrace, thereby decreasing its effectiveness at controlling erosion.
- 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.
- 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.
- Vegetation, where specified, shall be maintained and trees and brush controlled by chemical or mechanical means.
- Keep machinery away from steep back sloped terraces. Keep equipment operators informed of all potential hazards.
- Eradicate or otherwise remove all rodents or burrowing animals. Immediately repair any damage caused by their activity.
- Immediately repair any vandalism, vehicular, or livestock damage to any earthfills, spillways, outlets, or other appurtenances.

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, Terrace.

USDA, NRCS. National Engineering Handbook, Part 650, Engineering Field Handbook, Chapter 9, Diversion.