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 to support one or both of the following:

- Reduce soil erosion
- Retain runoff for moisture conservation

CONDITIONS WHERE PRACTICE APPLIES

This practice applies where:

- Soil erosion by water 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.
- Excess runoff is a problem.
- There is a need to improve overall water quality.

CRITERIA

Laws, rules, and regulations. This practice shall conform to all federal, state, and local laws, rules, and regulations. Laws, rules, and regulations of particular concern include those involving water rights, land use, pollution control, property easements, wetlands, preservation of cultural resources, and endangered species.

Spacing - Terraces for erosion control. The maximum spacing for terraces for erosion control shall be determined by one of the following methods:

1. 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 Figures 1 and 2)
   x = 0.6 throughout Kansas
   s = land slope in percent
   y = a variable with values from 1 to 4

   Values of y are influenced by soil erodibility, cropping system, and crop management practices. A value of 1 shall be selected for erodible soils with tillage systems that provide little or no cover during periods of intense rainfall. A value of 4 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 is unfavorable. Other values between 1 and 4 may be used according to the estimated quality of the factors. The terrace spacing does not have to be less than 90 feet.

2. Revised Universal Soil Loss Equation (RUSLE) - The horizontal interval 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.

   The horizontal interval as determined by either of the above methods should not exceed that shown in Table 2 for the condition shown. The maximum limits may

not be exceeded when making adjustments indicated below.

The 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.

The likelihood of benching of steep slopes by tillage, land forming, and erosion shall be considered when determining the terrace interval. For example, use the proposed as-built slope and length in RUSLE calculations.

Spacing - Terraces for water conservation. For level terraces used for erosion control and water conservation, the horizontal interval shall be determined as previously described, but in no case shall the maximum horizontal interval exceed 600 feet. An "x" value of 0.8 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 define the horizontal interval or erosion length to be used in calculating terrace spacing.

Drainage area - Top terrace. The drainage area above the top terrace of a system shall not exceed the area that would be drained by a terrace of equal length with normal spacing.

Table 1 - Terrace P factors

Horizontal Interval (feet)	Closed Outlets [1/]	Open Outlets, with Percent Grade of [2/]					
		0.1	0.2	0.4	0.6	0.8	>0.8
<100	.48	.52	.54	.61	.72	.90	1.00
105	.51	.55	.57	.63	.73	.91	1.00
120	.58	.62	.63	.69	.77	.92	1.00
135	.64	.67	.69	.73	.81	.94	1.00
150	.70	.72	.74	.77	.84	.94	1.00
180	.78	.80	.81	.84	.88	.96	1.00
210	.84	.86	.86	.88	.92	.97	1.00
240	.89	.90	.90	.92	.94	.98	1.00
270	.92	.93	.93	.94	.96	.99	1.00
300	.94	.95	.95	.96	.97	.99	1.00
400	.98	.98	.98	.99	.99	1.00	1.00
500	.99	.99	.99	1.00	1.00	1.00	1.00

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

[1/] Applies to terraces with underground outlets, to level terraces with open outlets, and to water and sediment control basins. (Sediment control basins that do not have a contour factor should not be given a terrace P subfactor.)

[2/] The average channel grade is calculated from 300 feet or 1/3 of the terrace length closest to the outlet, whichever is less.

Table 2 - Maximum horizontal interval for terraces

Land Slope (percent)	RUSLE (feet)	With Contour Stripcropping (feet)
0-2	450	600
2-4	300	600
4-6	200	600
6-9	150	400
9-12	150	250
12-18	150	150
More than 18	150	150
Minimum spacing required, all slopes	90	90

Capacity. The terrace shall have enough capacity to control the runoff from a 10-year frequency, 24-hour storm without overtopping. For closed end level and all underground outlet terraces, the capacity shall be increased by the estimated 10-year sediment accumulation as determined by RUSLE or by the Kansas supplement to Chapter 8 of National Engineering Handbook (NEH) Part 650, Engineering Field Handbook, unless sediment is removed through maintenance. 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 V is calculated using Manning's equation, a roughness coefficient "n" value of 0.06 shall be used for bare channels.

where:

Q = capacity in cubic feet per second (cfs)
A = area in feet squared (ft^2)

Chapter 7 of NEH Part 650; Agricultural Research Service (ARS) Agricultural Handbook 667, Stability Design of Grass-lined Open Channels; or equivalent shall be used for vegetated channels.

The Kansas Supplement to Chapter 8 of NEH Part 650 provides sediment and detention storage values to be used in the design of underground outlet terraces.

Cross section. The terrace cross section shall be proportioned to fit the land slope and the farm machinery used. The minimum cross section shall have a design height of 1 foot, crown width of 3 feet, cut slope of 5:1, and ridge slopes of 5:1 (except the back slope of steep back slope and the ridge slopes of narrow-based terraces may be 2:1).

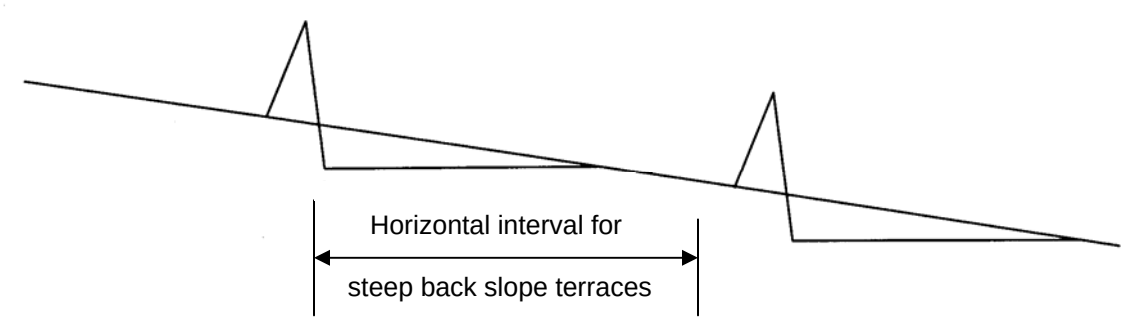

Figure 1 - Horizontal interval for steep back slope terraces

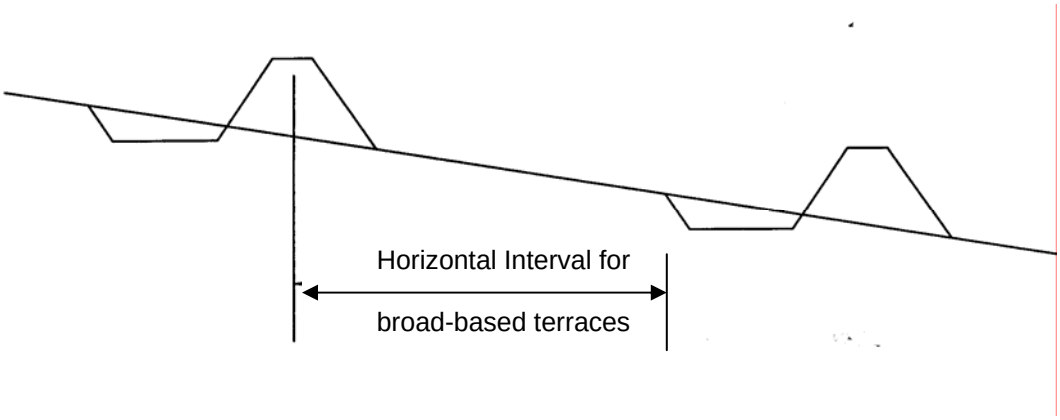

Figure 2 - Horizontal interval for broad-based terraces

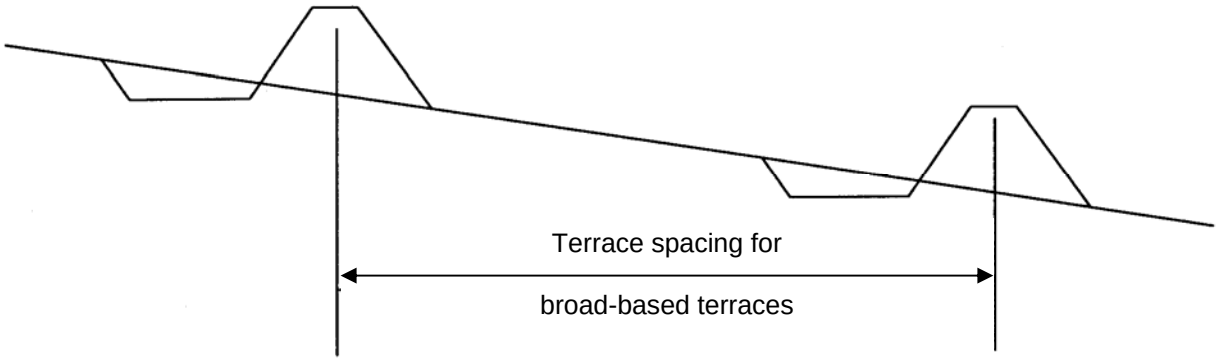

Figure 3 - Terrace spacing for broad-based terraces

The terrace type shall be selected from the following cross sections based on the land slope. Broad-based terraces (as shown in Figures 2, 3, and 4) may be used on land up to 10 percent slope. Narrow-based terraces (2:1 front and back slope, both slopes grassed) may be used on land up to 12 percent. Terraces built with borrow from the uphill side tends to increase the land slope between terraces on the steeper land and less earthfill is required in the terrace ridge because part of the capacity is in the excavation.

Grass-back terraces (steep back slope terraces shown in Figure 1) and narrow -based terraces with the majority of the borrow taken from the downhill side may be used on land up to 20 percent slope. Where borrow is taken from the downhill side, the land is more farmable as the land slope between terraces is reduced. Borrow from both sides reduces the terrace ridge height and the yardage as compared to terraces built entirely from the lower side.

The construction height (minimum design height) will be the height required for the design storage plus a minimum of 0.3 foot for settlement, channel sediment deposits, ridge erosion, the effect of normal tillage operations, and safety.

Terrace ridges, especially those with steep back slopes, can be very hazardous. All cropped terrace slopes that are to be farmed shall be 5:1 or flatter for safe operation of the farm equipment. Potential hazards must be brought to the attention of the responsible person.

The opening at the outlet end of gradient and open-end level terraces shall have a cross section equal to that specified for the terrace channel.

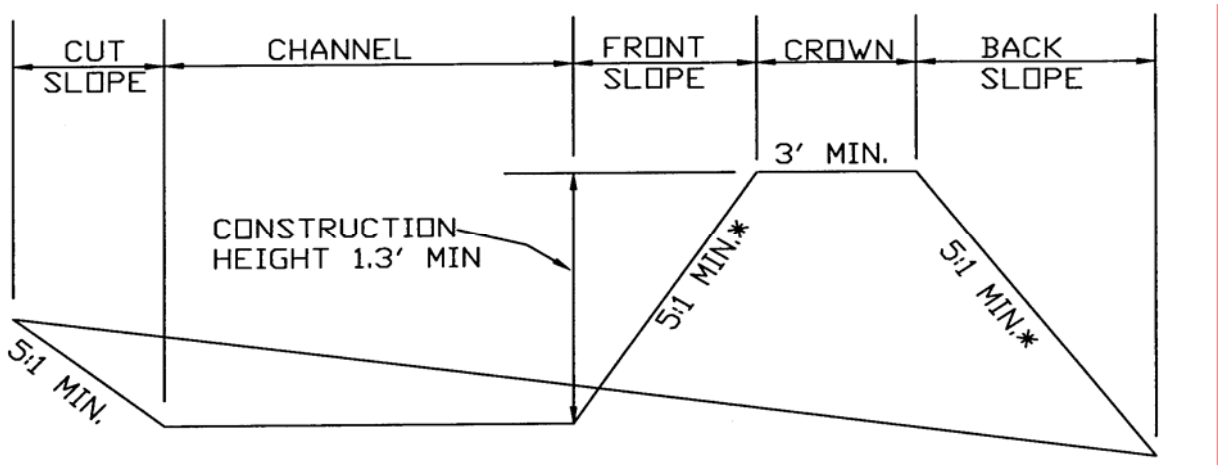

Figure 4 - Minimum terrace cross section

* Steep back slope and narrow-based terraces may be 2:1.

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. Open ends and partial end closures shall have a vegetated or other stable outlet.

If terraces with partial- or closed-end closures 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 end closure before overtopping the terrace ridge.

Partial-end closures shall not be more than half the constructed height of the terrace. Complete-end closures (blocks) shall be at the height of the storage depth required by the design. The cross section of the closures may be less than the terrace cross section.

Alignment. Cropland terraces shall be parallel (if feasible) or as parallel as practical consistent with the land user's desires. Curves shall be long and gentle (when conditions allow) to accommodate farm machinery.

Channel grade. Channel grade may be either uniform or variable. The overall terrace grade shall not exceed 0.4 percent unless the alignment is significantly improved. In order to improve alignment and reach a more suitable terrace design, grades may be varied by sections of terrace. A maximum average grade of 0.9 percent is acceptable for the first 300 feet of terrace nearest the upper end or divide, 0.7 percent from 300 to 600 feet, 0.5 percent from 600 to 900 feet, and 0.4 percent from 900 feet to the outlet (except that a 0.8-foot fall is permitted in the last 100 feet and may be excluded in determining the average terrace grade).

To avoid excessive channel wetness, terraces constructed on hydrologic group D soils shall have 0.1 percent minimum grade for areas of average annual rainfall of 35 inches or less and 0.2 percent minimum grade for areas of more than 35 inches average annual rainfall.

Maximum channel velocity for farmed channels shall be non-erosive for the soils and planned treatment. Maximum velocity for erosion-resistant soils is 2.5 feet per second (fps); for average soils, 2.0 fps; and for easily erodible soils, 1.5 fps. Refer to Chapter 9 (Table 9-1) of NEH Part 650. Maximum velocity shall be computed by using Manning's equation roughness coefficient "n" value of 0.035.

Maximum channel velocities for permanently vegetated channels shall not exceed those used for grassed waterways.

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 feet unless the channel is blocked (complete end closure) at intervals not exceeding 3,500 feet.

The capacity and the non-erosive velocity requirements will control the gradient terrace length. The minimum ridge height and channel bottom widths for terraces of varying length and horizontal spacing can be determined from the "Design Guide for Gradient Terrace" in the Kansas supplement to Chapter 8 of NEH Part 650.

Outlets. All terraces must have adequate outlets. Vegetated outlets may be used for gradient terraces or level terraces with open-end or partial end closures. Such an outlet may be a grassed waterway or other vegetated area that has adequate capacity and stability. The outlet must convey runoff water to a point where the outflow will not cause damage. Outlets shall be installed and vegetation established before the terrace is constructed to provide a stable, non-erodible 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. An orifice plate, a conduit of increased size, or other features shall be installed as needed to control the release rate and prevent excessive pressure in the conduit. The outlet discharge when combined with the storage of the terrace 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 and, in no case, be greater than 60 hours. If sediment retention is desired, adjust release rate according to particle size.

The underground conduit shall meet the requirements specified in Conservation Practice Standards 620, Underground Outlets, or 606, Subsurface Drains. Conduits must be installed deep enough to prevent damage and crushing 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 an outlet for level terraces if the soil is homogenous and deeper than 3 feet below the constructed channel. Soil infiltration must permit draining the design storm from the terrace channel within a reasonable period so standing water does not significantly damage crops. Generally, only soils of the 0.5 intake family or greater should be used as outlets; however, 0.3 intake soils may be used where experience in the area indicates

acceptability. Channels of 0.3 intake shall be deep ripped a minimum of 6 inches.

Landuser desires, soil parameters, rainfall runoff, crops, management, irrigation, and farm equipment are to be considered when establishing the allowable tolerance between the high and low points in the channel of level terraces. Unless the conditions dictate a lesser amount, the maximum tolerance of all level terraces is 1 foot for channel widths of 30 feet or less and 0.4 foot for channel widths greater than 30 feet.

Terrace outlet structures may be used on gradient or level terraces. The terrace outlet structure shall meet the requirements as shown on Form KS-ENG-438(JS) in the Kansas supplement to Chapter 6 of NEH Part 650. Terrace outlet structures shall have adequate capacity for the design flow from the terrace and any upstream drainage or terrace outlets. The outlet shall be designed such that there is adequate tailwater to prevent erosion below the structure. The grade between structures shall be adequate to avoid excessive channel wetness and to ensure that no erosion occurs between structures. The maximum allowable grade between terrace outlet structures is 0.3 percent.

Combinations of different types of outlets may be used on the same system to maximize water conservation, to improve water quality, and to make a more farmable system that provides an economical installation.

Vegetation. Steep back slope and narrow-based terraces shall be established to grass as soon as practical after construction. The sod shall be maintained, and trees and brush shall be controlled by chemical or mechanical means.

Selected species of shrubs favorable to wildlife are sometimes planted in a solid or intermittent row near the toe of the back slope.

The establishment of vegetation shall comply with Conservation Practice Standard 342, Critical Area Planting.

Terrace Restoration. Terraces are considered to be nonfunctional when any of the following exists:

1. The existing terrace system has horizontal intervals that are wider than allowed by current criteria and has soil loss in excess of allowable T.
2. The existing cross sectional storage area for level or storage-type terraces is less than 50 percent of the storage area at the constructed design height that would comply with this standard.
3. The existing cross sectional flow area for gradient terraces has the capacity to carry less than 50 percent of the design discharge without overtopping or a minimum of 0.5 foot of height.

Supporting data is to be prepared that clearly shows the system is or is not functional in accordance with the above criteria. Restored terraces shall be designed in accordance with this standard.

CONSIDERATIONS

Consider adjusting the spacing to allow an even number of trips with the equipment.

For level terraces, consider installing with open ends or other discharging outlets to not affect the hydrology of potential playa lake wetlands.

PLANS AND SPECIFICATIONS

Plans and specifications for installation of terraces shall be in keeping with this standard and shall describe the requirements for application of the practice to achieve its intended purpose. Construction operations shall be carried out 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 as follows:

- Provide periodic inspections, especially immediately following runoff events.
- Promptly repair or replace damaged components as necessary.
- Maintain terrace ridge height and outlet elevations.
- Remove sediment that has accumulated in the terrace to maintain capacity and, for a gradient terrace, to maintain a positive channel grade.

- 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.
- Vegetated outlets should be established before construction when feasible.
- Keep machinery away from steep back slopes on terraces. Keep equipment operators informed of all potential hazards.
- Control burrowing animals in vegetated terraces.