Other Forms of Terraces

• Subsurface outlet terraces
  – Used in combination with tile drainage systems
  – Holds water long enough to let sediment settle but not so long as to cause crop damage.

http://www.agry.purdue.edu/soils_judging/new_manual/ch3-water.html
Flat Top Terraces

• Used on steep slopes to gain arable land

http://lrc.salemstate.edu/pictures/ipc2011/imagepages/image51.htm
General Design Requirements For Terraces

• Spacing:
  – Maximum spacing is that which will reduce soil erosion to below soil loss tolerance (T value).

• Channel Length:
  – Must be short enough to prevent excess concentration and velocity at outlet

• Channel Grade:
  – Water velocity must be low enough to prevent channel erosion but fast enough to prevent water logging or delay in field activities

• Channel Capacity:
  – Sufficient to control runoff from a 10 year frequency 24 hour storm
Terrace Spacing

• Calculate soil loss using RUSLE or the WEPP hill slope erosion model for 30 year average (RUSLE is currently used by NRCS)
  – If above \( T \) value, terraces are warranted.
  – Spacing is equal to slope length at which soil loss is below \( T \)

• NRCS also uses an empirical equation to determine spacing

\[ HI = \frac{(X*S+Y)100}{S} \]

\[ VI = X*S*Y \]

\( VI \) = Vertical interval
\( HI \) = Horizontal interval
\( X \) = is based on geographical location
\( Y \) = soil condition
\( S \) = slope (%)
Vertical and Horizontal Interval

• HI must be used for parallel terraces
  – May be used on steep slopes where narrow base terraces are needed
  – Facilitate field activities

• VI is used for terraces that follow slope
  – Most common in OK
X Values

- Dependent on the quantity and intensity of Rainfall

This figure is for calculation of HI in meters
For HI in ft $x=0.4, 0.5, 0.6, 0.7$ and $0.8$

Fig. 11.15 Values for geographical location ($X$) in Eq. (11.7) for the USA (After ASAE, 2003)
Y Values

- Dependent on soil erodibility and ground cover
- Combined with slope this replaces the need to estimate erosion

<table>
<thead>
<tr>
<th>Ground Cover</th>
<th>Soil Erodibility Factor (K)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0-0.20</td>
</tr>
<tr>
<td>10%</td>
<td>2.5</td>
</tr>
<tr>
<td>40%</td>
<td>3.25</td>
</tr>
<tr>
<td>80%</td>
<td>4.0</td>
</tr>
</tbody>
</table>
Terrace Grade

- Must be sufficient to prevent damage to crops yet not cause channel erosion
- At the upper part of the terrace, grade can be as high as 1.5 to 2 %
- The grade may decrease as the terrace becomes longer to prevent excessive water velocity
Terrace Length

- As the terrace length increases the water velocity will increase
- 1800-2000 ft is the maximum distance that a terrace should drain in one direction.
  - Distances longer than this will require very shallow grades to reduce velocity
    - Can cause problems with drainage near outlet
Channel Capacity

• Terrace channel must be designed to control (graded terraces) or contain (flat channel) a 10 year 24 hour rainstorm event.

• Graded terraces should be designed to carry the water at low velocities
Cross Sectional

• Side slopes \((h/(0.5b))\) will influence water velocity
  – Shallow side slopes decrease velocity
  – This allows terrace grade to be increased
  • Providing better drainage
Manning’s Equation

\[ V = \frac{R^{2/3}S^{1/2}}{n} \]

Continuity Equation
\[ Q = A \times V \]

- **R** = hydraulic radius of water way (m) = cross sectional area/wetted perimeter
- **S** = Waterway slope
- **n** = manning’s coefficient of roughness
- **Q** = Flow rate (m\(^3\)/s) [peak discharge]
- **A** = cross sectional area of water way (m\(^2\))
- **V** = velocity of runoff (m/s)

To prevent channel erosion the following velocities should be used:

- 0.8 m/s for clays, 0.6 m/s for loamy soils and 0.45 m/s for sandy soils.
Cross Sectional Area

• Most commonly, broad based terraces should have the following dimensions:
  • $h=0.3\text{m} \ (1\text{ft})$ this includes free board
  • $b=10\text{m} \ (32\text{ ft})$

![Diagram showing cross-sectional area with labels $h$, $b$, and $c$.]
Removing Terraces

• Dramatically increases water velocity in terrace channel
  – Can cause scouring

• Increased probability over topping terraces
  – Can result in Gullies

• No-till will simply reduce maintenance and reduce damage from large events
Terrace Maintenance

• Maintenance is needed to remove sediment from channel and maintain height
• Can be done with a moldboard plow or grading equipment
• Must also evaluate terrace outlet to determine if sediment accumulation is obstructing flow
• Channel grade may also need to be corrected
Sedimentation of Channel

- Approximately 4 inches of sediment from 2011-12 wheat crop year
- Rill erosion off hill slope
Sediment Removal

- Most often achieved with a MoldBoard
- Will not correct channel grade
Terrace Maintenance

• New RTK guided technology is also being used
  – Initial developed for construction
  – Then adapted to use in rice production
  – Can be adapted to grade terraces
Terrace Maintenance

- Biggest problem with terraces is improper channel grade

Channel Length = 1600 ft.

Will Hold water and perhaps flow over the terrace
Improper drainage

• Water log conditions
  – Restrict field operations and reduce yield
Crop Damage is very Common

- Zero yield near outlet
Crop Damage is very Common
RTK system

• Dr. Taylor Video