Level III: Design of Erosion & Sediment Control Plans

- Class materials
  - [https://www.bae.ncsu.edu/workshops-conferences/level-iii/](https://www.bae.ncsu.edu/workshops-conferences/level-iii/)
- Certification test (~1.5 hours)
- Test results take 4-7 weeks to get posted

Level III: Erosion & Sediment Certification Design of Erosion & Sediment Control Plans

1. Hydrology
2. Erosion
3. Regulatory Issues
4. Open Channel Design
5. Sediment Retention BMPs
6. Below Water Table Borrow Pits
MODULE 1. Hydrology: Peak Runoff Rate

- Rainfall in/hr
- Peak Runoff Rate
- Hydrograph
- Contributing Watershed
- Point of Interest

Time
**Watershed Definitions**

- Water runs down slope and perpendicular to contour lines
- Point of Interest (POI) is the location for which you are computing the runoff/discharge (peak flow for a BMP)
- Most Remote Point (MRP) is the most distant point from the POI
- Watershed drainage area is the total land area that drains to POI (determined from a map)

USGS Topo Maps: topomaps.usgs.gov
ACME Mapper: mapper.acme.com
Runoff Hydrograph Estimation Methods

Two common methods:

**Rational Method:**
- Peak Runoff Rate

**Soil-Cover-Complex (SCS):**
- Runoff Volume
- Peak Runoff Rate

*Never combine these methods*

### Rational Method for Estimating Peak Runoff Rate

\[ Q = (C) (i) (A) \]  
*(Equation 1.1)*

- \( Q \) = peak runoff or discharge rate in cubic feet per second (cfs),
- \( C \) = runoff coefficient (decimal ranging from 0 to 1),
- \( i \) = rainfall intensity (in/hr) for a given return period design storm, and
- \( A \) = watershed drainage area in acres (ac).

**Examples:**
- 10-year peak runoff, \( Q_{10} = 30 \) cfs
- 25-year peak runoff, \( Q_{25} = 45 \) cfs
Rainfall Intensity

1. Return period for design storm:

\[ T = \frac{1}{P} \]  

(Equation 1.2)

- \( P \) = probability of a precipitation event being exceeded in any year,
- \( T \) = return period for a specific hydrologic event (years).

**Example:** Return period for a rainfall event that has a 0.10 (10%) probability of being exceeded each year is:

\[ T = \frac{1}{0.10} = 10\text{-yr return period} \]

2. Duration for design storm:

Equal to time of concentration (\( T_c \))

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Time of Concentration, \( t_c \)

Time for water to travel from the Most Remote Point (MRP) to the Point of Interest (POI)

**Methods for estimating \( t_c \)**

1. Jarrett Shortcut Method
2. Segmental Method (TR-55)

**Need to Know:**

1. Watershed Area, \( A \) (acres)
2. Flow Length from MRP to POI, \( L \) (ft)
3. Elevation Drop from MRP to POI, \( H \) (ft)
4. Land Use (assume graded, unpaved)
**Jarrett Shortcut Method: \( t_c \)**

\[
S = \frac{H}{L_{\text{flow}}}
\]  \hspace{1cm} (Equation 1.3)

- \( S \) = average watershed slope (ft/ft),
- \( H \) = elevation change from most remote point to point of interest (ft), and
- \( L_{\text{flow}} \) = flow length from most remote point to point of interest (ft).

\[
A_{\text{Jarrett}} = 460 \times (S)
\]  \hspace{1cm} (Equation 1.4)

- \( A_{\text{Jarrett}} \) = Jarrett Maximum Area in acres (ac), and
- \( S \) = average watershed slope (ft/ft).

If the watershed area is less than the Jarrett Maximum Area, then \( t_c = 5 \) min.
Jarrett Shortcut Method: $t_c$

*Example:* For a watershed drainage area of 5 acres with an elevation drop of 10 ft over a flow length of 500 ft, what is the average slope and the Jarrett Maximum Area?

\[
\text{Slope, } S = \frac{H}{L_{\text{flow}}} = \frac{10}{500} = 0.02 \text{ ft/ft}
\]

Jarrett Max Area, $A_{\text{Jarrett}} = 460 \times (0.02) = 9.2 \text{ acres}$

Since the watershed drainage area of 5 acres < 9.2 acres, use $t_c = 5 \text{ min}$

*Example:* For a watershed drainage area of 7 acres with an elevation drop of 8 ft over a flow length of 720 ft, what is the average slope and the Jarrett Maximum Area?

\[
\text{Slope, } S = \frac{H}{L_{\text{flow}}} = \frac{8}{720} = 0.011 \text{ ft/ft}
\]

Jarrett Max Area, $A_{\text{Jarrett}} = 460 \times (0.011) = 5.1 \text{ acres}$

Since the watershed drainage area of 7 acres > 5.1 acres, the Jarrett Shortcut does not apply, and a different method must be used.

---

NRCS Segmental Method (TR-55)

**Shallow Concentrated Flow**

Unpaved Areas: $t_c = 0.001 \left( \frac{L_{\text{flow}}}{S} \right)^{0.53}$ \hspace{1cm} (Equation 1.5)

Paved Areas: $t_c = 0.0008 \left( \frac{L_{\text{flow}}}{S} \right)^{0.53}$ \hspace{1cm} (Equation 1.6)

$t_c = \text{time of concentration in minutes (min)}, \hspace{1cm} L_{\text{flow}} = \text{flow length from most remote point to point of interest (ft)}, \hspace{1cm} S = \text{average watershed slope (ft/ft)}.$

Note: Kirpich (1940) is another method
NRCS Segmental Method (TR-55)
Shallow Concentrated Flow

Example: For a construction site watershed drainage area of 10 acres with an elevation drop of 12 ft over a flow length of 1000 ft, estimate time of concentration.

\[ S = \frac{H}{L_{\text{flow}}} = \frac{12}{1000} = 0.012 \text{ ft/ft} \]

Assume that the area is unpaved, therefore use Equation 1.5:

\[ t_c = 0.001 \left( L_{\text{flow}} \right) / S^{0.53} = 0.001 \left( 1000 \right) / 0.012^{0.53} = 10.4 \text{ minutes} \]

Use \( t_c = 10 \) minutes

If the elevation drop for this site was 30 ft, the calculated value for \( t_c \) would be 6.4 minutes. In that case, use a \( t_c \) value of 5 minutes for determining rainfall intensity since the lower \( t_c \) produces a higher rainfall intensity and a more conservative estimate of peak runoff rate and basin size.

Rainfall Intensity (in/hr): Table 1.1
http://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=nc
Rainfall Data

Need Intensity by Return Period and Duration

Listed for some locations in Table 1.1

**POINT PRECIPITATION FREQUENCY (PF) ESTIMATES**
WITH 90% CONFIDENCE INTERVALS AND SUPPLEMENTARY INFORMATION
NOAA Atlas 14, Volume 2, Version 3

<table>
<thead>
<tr>
<th>Duration</th>
<th>1/2</th>
<th>1/5</th>
<th>1/10</th>
<th>1/25</th>
<th>1/50</th>
<th>1/100</th>
<th>1/200</th>
<th>1/500</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-min</td>
<td>5.18</td>
<td>6.34</td>
<td>7.14</td>
<td>7.92</td>
<td>8.46</td>
<td>8.94</td>
<td>9.34</td>
<td>9.79</td>
</tr>
<tr>
<td></td>
<td>(4.76, 5.66)</td>
<td>(6.03, 6.81)</td>
<td>(6.54, 7.76)</td>
<td>(7.22, 9.03)</td>
<td>(7.06, 9.19)</td>
<td>(8.06, 9.72)</td>
<td>(8.40, 10.2)</td>
<td>(8.74, 10.7)</td>
</tr>
<tr>
<td>10-min</td>
<td>4.15</td>
<td>5.08</td>
<td>5.71</td>
<td>6.31</td>
<td>6.73</td>
<td>7.10</td>
<td>7.41</td>
<td>7.73</td>
</tr>
<tr>
<td></td>
<td>(3.82, 4.53)</td>
<td>(4.87, 5.54)</td>
<td>(5.23, 6.22)</td>
<td>(5.76, 6.87)</td>
<td>(6.11, 7.33)</td>
<td>(6.41, 7.72)</td>
<td>(6.66, 8.07)</td>
<td>(6.91, 8.45)</td>
</tr>
<tr>
<td>15-min</td>
<td>3.46</td>
<td>4.25</td>
<td>4.81</td>
<td>5.33</td>
<td>5.69</td>
<td>5.98</td>
<td>6.23</td>
<td>6.50</td>
</tr>
<tr>
<td></td>
<td>(3.20, 3.80)</td>
<td>(3.94, 4.68)</td>
<td>(4.15, 5.29)</td>
<td>(4.87, 6.11)</td>
<td>(5.16, 6.18)</td>
<td>(5.40, 6.81)</td>
<td>(5.60, 7.07)</td>
<td>(5.60, 7.09)</td>
</tr>
<tr>
<td>30-min</td>
<td>2.40</td>
<td>3.04</td>
<td>3.49</td>
<td>3.95</td>
<td>4.28</td>
<td>4.58</td>
<td>4.85</td>
<td>5.18</td>
</tr>
<tr>
<td></td>
<td>(2.21, 2.63)</td>
<td>(2.80, 3.32)</td>
<td>(3.20, 3.80)</td>
<td>(3.61, 4.30)</td>
<td>(3.89, 4.66)</td>
<td>(4.14, 4.99)</td>
<td>(4.36, 5.29)</td>
<td>(4.61, 5.94)</td>
</tr>
<tr>
<td>60-min</td>
<td>1.51</td>
<td>1.95</td>
<td>2.27</td>
<td>2.63</td>
<td>2.90</td>
<td>3.16</td>
<td>3.40</td>
<td>3.71</td>
</tr>
<tr>
<td></td>
<td>(1.39, 1.65)</td>
<td>(1.79, 2.13)</td>
<td>(2.08, 2.41)</td>
<td>(2.40, 2.86)</td>
<td>(2.50, 3.14)</td>
<td>(2.80, 3.43)</td>
<td>(3.06, 3.71)</td>
<td>(3.31, 4.05)</td>
</tr>
</tbody>
</table>

AMS-based precipitation frequency estimates with 90% confidence intervals (in inches/hour)

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**Runoff Coefficient, C**

Table 1.2. Rational Method C for Agricultural Areas. (Taken from Schwab et al., 1971).

<table>
<thead>
<tr>
<th>Vegetation</th>
<th>Runoff Coefficient, C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sandy Loam</td>
</tr>
<tr>
<td>Slope</td>
<td></td>
</tr>
<tr>
<td>Forest/wooded</td>
<td></td>
</tr>
<tr>
<td>0-5% slope</td>
<td>0.10</td>
</tr>
<tr>
<td>5-10% slope</td>
<td>0.25</td>
</tr>
<tr>
<td>10-30% slope</td>
<td>0.30</td>
</tr>
<tr>
<td>Pasture/grass</td>
<td></td>
</tr>
<tr>
<td>0-5% slope</td>
<td>0.10</td>
</tr>
<tr>
<td>5-10% slope</td>
<td>0.16</td>
</tr>
<tr>
<td>10-30% slope</td>
<td>0.22</td>
</tr>
<tr>
<td>Cultivated/bare soil</td>
<td></td>
</tr>
<tr>
<td>0-5% slope</td>
<td>0.30</td>
</tr>
<tr>
<td>5-10% slope</td>
<td>0.40</td>
</tr>
<tr>
<td>10-30% slope</td>
<td>0.52</td>
</tr>
</tbody>
</table>
Area-Weighted Average C value

*Example:* Determine the weighted average runoff coefficient, \( C \), for a 4-acre watershed with 1 acre of grassy field on clay soil at 3% slope and 3 acres of active construction on clay soil at 4% slope.

<table>
<thead>
<tr>
<th>Land Cover</th>
<th>A</th>
<th>C</th>
<th>((A)(C))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pasture</td>
<td>1</td>
<td>0.40</td>
<td>0.40</td>
</tr>
<tr>
<td>Bare Soil</td>
<td>3</td>
<td>0.60</td>
<td>1.80</td>
</tr>
<tr>
<td>TOTAL</td>
<td>sum = 4</td>
<td>sum = 2.20</td>
<td></td>
</tr>
</tbody>
</table>

Weighted \( C = \frac{2.20}{4} = 0.55 \)

For this example, estimate \( Q \) if rainfall intensity, \( i = 5.80 \) in/hr:

\[
Q = (C) (i) (A) = (0.55) (5.80) (4) = 12.8 \text{ cfs}
\]

---

*Example: Rational Method*

Determine the 10-year peak runoff rate, \( Q_{10} \), for a 5-acre construction site watershed near Asheville with a flow length = 600 ft and elevation drop = 36 ft. The land uses are shown below:

<table>
<thead>
<tr>
<th>Land Use</th>
<th>A</th>
<th>C</th>
<th>((A)(C))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest, clay (11%)</td>
<td>1</td>
<td>0.60</td>
<td>0.60</td>
</tr>
<tr>
<td>Bare soil, clay (7%)</td>
<td>3</td>
<td>0.70</td>
<td>2.10</td>
</tr>
<tr>
<td>Grass, clay (3%)</td>
<td>1</td>
<td>0.40</td>
<td>0.40</td>
</tr>
<tr>
<td>TOTAL</td>
<td>sum = 5 ac</td>
<td>sum = 3.10</td>
<td></td>
</tr>
</tbody>
</table>

Weighted Runoff Coefficient: \( C = \frac{3.10}{5} = 0.62 \)

Average watershed slope, \( S = \frac{36}{600} = 0.06 \text{ ft/ft} \)

Jarrett Max Area = \( 460 (0.06) = 27.6 \text{ ac} \); Since \( 5 < 27.6 \), use \( t_c = 5 \) min

Rainfall intensity for 10-year storm, \( i_{10} \), is determined from Table 1.1 for a 5-minute rainfall in Asheville: \( i_{10} = 6.96 \text{ in/hr} \)

\[
\text{Peak runoff rate, } Q_{10} = (0.62) (6.96) (5) = 21.6 \text{ cfs}
\]
**Example: Rational Method**

Determine the 25-year peak runoff rate, \( Q_{25} \), for a 4-acre construction site watershed near Charlotte with a flow length = 500 ft and elevation drop = 20 ft. The Runoff Coefficient, \( C \) = 0.60 (cultivated tight clay soil)

Average watershed slope, \( S = \frac{20}{500} = 0.04 \text{ ft/ft} \)

Jarrett Max Area = 460 (0.04) = 18.4 ac; Since 4 < 18.4, use \( t_c = 5 \text{ min} \)

Rainfall intensity for 25-year storm, \( i_{25} \), is determined from Table 1.1 for a 5-minute rainfall in Charlotte: \( i_{25} = 8.00 \text{ in/hr} \)

**Peak runoff rate,** \( Q_{25} = (0.60)(8.00)(4) = 19.2 \text{ cfs} \)

---

**Emphasis on Diverting ‘Clean’ Runoff**
Worksheet

1.1 Estimate the 25-year return period peak runoff rate from a watershed near Greensboro that is 5x1.96 inches on a map (scale: 1inch=200ft). The watershed has an average slope of 5.5% and a weighted average runoff coefficient of 0.65.

\[
C = 0.65 \\
A = 9 \text{ ac (1000ft x 392 ft)} \\
t_c = 5 \text{ min } [A_{\text{Jarrett}} = 460 (0.055) = 25 \text{ which is greater than 9}] \\
i_{25} = 7.46 \text{ in/hr} \\
Q_{25} = (C) (i) (A) = (0.65) (7.46 \text{ in/hr}) (9 \text{ ac}) = 44 \text{ cfs}
\]

Worksheet

1.2. Estimate the 10-year peak runoff rate, \(Q_{10}\), for a 20-acre construction site watershed near Raleigh with a flow length = 2000 ft and elevation drop = 60 ft. The land uses are half forest and half bare soil. Assume tight clay.

<table>
<thead>
<tr>
<th>Land Use</th>
<th>A</th>
<th>C</th>
<th>(A) C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest</td>
<td>10</td>
<td>0.40</td>
<td>4.0</td>
</tr>
<tr>
<td>Bare soil</td>
<td>10</td>
<td>0.60</td>
<td>6.0</td>
</tr>
</tbody>
</table>

\[\text{sum = 20 ac} \quad \text{sum = 10.0}\]

Weighted Runoff Coefficient: \(C = 10 \div 20 = 0.5\)
Average watershed slope, \(S = 60 \div 2000 = 0.03 \text{ ft/ft}\)
Jarrett Max Area = 460 (0.03) = 13.8 ac; Since 13.8 < 20, use other method
Segmental Method: \(t_c = 0.001 (2000) / 0.03^{0.53} = 12.8 \text{ min}\); use \(t_c = 10 \text{ min}\)
Rainfall intensity, \(i_{10} = 5.58 \text{ in/hr}\)
Peak runoff rate, \(Q_{10} = (0.5) (5.58) (20) = 56 \text{ cfs}\)
MODULE 2. Erosion and Sediment Control

- Erosion Principles
- Erosion Control Planning
  - RUSLE: R, K, LS, CP

Erosion Principles: Detachment and Transport

*Detachment from…*  
- Rain  
- Flowing water  
- Tillage  
- Earthmoving

*Transport from…*  
- Flowing water  
- Wind  
- Sloughing of steep slopes
Factors Influencing Erosion

- Climate: Precipitation, freezing
- Soil Characteristics:
  - Texture
  - Structure
  - Organic matter
  - Permeability
- Land Shape:
  - Slope
  - Length of Slope
- Land Use:
  - Land cover, BMPs

Erosion Planning: USLE / RUSLE

\[ A_{\text{erosion}} = (R) (K) (LS) (CP) \]  
(Equation 2.1)

\[ A_{\text{erosion}} = \text{longterm annual soil interrill + rill erosion in tons per acre per year (tons/ac-yr)}, \]
\[ R = \text{rainfall factor (dimensionless)}, \]
\[ K = \text{soil erodibility factor (dimensionless)}, \]
\[ LS = \text{slope-length factor (dimensionless)}, \]
\[ CP = \text{conservation practice(s) factor (dimensionless)} \]
R, Rainfall Factor

- Represents rainfall energy that causes erosion
- Higher R = higher erosion potential
- Annual R values, Figure 2.1

Rainfall Energy Distribution

Varies by location: 3 zones in NC, Figure 2.2
Rainfall Energy Distribution

Varies by month due to storm intensity, Table 2.1

*Example (Piedmont):* April-July (4 months)

Partial-year fraction = 0.06 + 0.07 + 0.11 + 0.20 = 0.49

<table>
<thead>
<tr>
<th>Month</th>
<th>Geographic Region, Figure 2.2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>110 &amp; 116</td>
</tr>
<tr>
<td>Jan</td>
<td>0.03</td>
</tr>
<tr>
<td>Feb</td>
<td>0.04</td>
</tr>
<tr>
<td>Mar</td>
<td>0.05</td>
</tr>
<tr>
<td>Apr</td>
<td>0.06</td>
</tr>
<tr>
<td>May</td>
<td>0.07</td>
</tr>
<tr>
<td>Jun</td>
<td>0.11</td>
</tr>
<tr>
<td>Jul</td>
<td>0.20</td>
</tr>
<tr>
<td>Aug</td>
<td>0.21</td>
</tr>
<tr>
<td>Sep</td>
<td>0.11</td>
</tr>
<tr>
<td>Oct</td>
<td>0.05</td>
</tr>
<tr>
<td>Nov</td>
<td>0.04</td>
</tr>
<tr>
<td>Dec</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Examples: Rainfall Factor, R

Determine Partial-Year R for Raleigh in March through May:

- Figure 2.1: Annual R value for Raleigh is 270
- Figure 2.2: Raleigh is located in Region 116
- Table 2.1: March-May, fraction R is 0.05 + 0.06 + 0.07 = 0.18
- Partial-year R for March-May (3 months) = (0.18) (270) = 49

*If the construction period is July-September:*

Partial-year R = (0.20 + 0.21 + 0.11) (270) = 140

Determine Partial-Year R for Charlotte in April through July:

- Figure 2.1: Annual R value for Charlotte is 230
- Figure 2.2: Charlotte is located in Region 116
- Table 2.1: Apr-Jul, fraction R is 0.06 + 0.07 + 0.11 + 0.20 = 0.44
- Partial-year R for Apr-Jul (4 months) = (0.44) (230) = 101
K, Soil Erodibility Factor

- Represents soil’s tendency to erode
- NRCS tables for most soils (Table 2.2)

<table>
<thead>
<tr>
<th>Soil</th>
<th>Series</th>
<th>Permeability</th>
<th>B-Horizon</th>
<th>RUSLE</th>
<th>RUSLE</th>
<th>RUSLE</th>
<th>RUSLE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>T</td>
<td>K(A)</td>
<td>K(B)</td>
<td>K(C)</td>
<td></td>
</tr>
<tr>
<td>Alley</td>
<td>B</td>
<td>0.6 to 2.0</td>
<td>2</td>
<td>0.15</td>
<td>0.24</td>
<td>0.24</td>
<td></td>
</tr>
<tr>
<td>Appling</td>
<td>B</td>
<td>0.6 to 2.0</td>
<td>4</td>
<td>0.24</td>
<td>0.28</td>
<td>0.28</td>
<td></td>
</tr>
<tr>
<td>Autryville</td>
<td>A</td>
<td>2.0 to 6.0</td>
<td>5</td>
<td>0.10</td>
<td>0.10</td>
<td>0.10</td>
<td></td>
</tr>
<tr>
<td>Badin</td>
<td>B</td>
<td>0.6 to 2.0</td>
<td>3</td>
<td>0.15</td>
<td>0.24</td>
<td>0.15</td>
<td></td>
</tr>
<tr>
<td>Belhaven</td>
<td>D</td>
<td>0.2 to 6.0</td>
<td>--</td>
<td>--</td>
<td>0.24</td>
<td>0.24</td>
<td></td>
</tr>
<tr>
<td>Cecil</td>
<td>B</td>
<td>0.6 to 2.0</td>
<td>4</td>
<td>0.24</td>
<td>0.28</td>
<td>-33</td>
<td></td>
</tr>
</tbody>
</table>

LS, Length Slope Factor (Figure 2.5)
CP, Cover-Conservation Practices Factor

Represents the effect of land cover & direction of rills/channels

Table 2.3 lists CP values (use high values)

<table>
<thead>
<tr>
<th>Bare soil condition</th>
<th>CP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Packed, smooth</td>
<td>1.00 a</td>
</tr>
<tr>
<td>Fresh disked</td>
<td>0.95 a</td>
</tr>
<tr>
<td>Rough (offset disk)</td>
<td>0.85 a</td>
</tr>
<tr>
<td>Cut</td>
<td></td>
</tr>
<tr>
<td>Loose to 12 inches, smooth</td>
<td>0.90 b</td>
</tr>
<tr>
<td>Loose to 12 inches, rough</td>
<td>0.80 b</td>
</tr>
<tr>
<td>Compacted by bulldozer</td>
<td>1.00 b</td>
</tr>
<tr>
<td>Compacted by bulldozer and tracked parallel to the contour</td>
<td>0.50 c</td>
</tr>
<tr>
<td>Rough, irregular tracked all directions</td>
<td>0.90 b</td>
</tr>
</tbody>
</table>

Surface Condition with No Cover

| Compact and smooth, scraped w/bulldozer or scraper up / down hill | 1.3 d |
| Compact and smooth, raked w/bulldozer root rake up and down hill | 1.2 d |
| Compact and smooth, scraped w/bulldozer or scraper across slope | 1.2 d |
| Compact and smooth, raked w/bulldozer root rake across slope     | 0.9 d |
| Loose as a disked plow layer                                  | 1.0 d |

Example: Erosion Estimate

Estimate erosion from a 5-acre site in Raleigh during March-May with R = 49. The site is 600 ft long with elevation drop of 48 ft, and soil type is Creedmoor.

Average slope = 48 / 600 = 0.08 ft/ft (8% slope)
Table 2.2: K value is 0.32 (assume B Horizon – subsoil)
Figure 2.3: LS value is 3.5 (slope length = 600 ft; slope = 8%)
Table 2.3: CP value is 1.0 (assume loose surface with no cover)

Erosion per acre = (49) (0.32) (3.5) (1.0) = 54.9 tons/acre (March-May)
Total erosion for 5 acres = (54.9) (5) = 274.5 tons (March-May)

If the construction period is July-September (partial-year R = 140):
Erosion per acre = (140) (0.32) (3.5) (1.0) = 157 tons/acre (Jul-Sep)
Total erosion for 5 acres = (157) (5) = 786 tons (Jul-Sep)
Secondary Road Erosion Estimate

\[ V_{ditch} = (C_{ditch}) \times (R) \times (K) \times (S_{ditch}) \]  
(Equation 2.2)

\[ V_{ditch} = \text{secondary road sediment volume expected in cubic feet per acre (ft}^3/\text{ac}), \]
\[ C_{ditch} = \text{regression constant for secondary roads dependent on ditch side slopes,} \]
\[ R = \text{Rainfall Factor for the duration of construction,} \]
\[ K = \text{Soil Erodibility Factor (B or C horizon),} \]
\[ S_{ditch} = \text{slope of secondary road ditch (ft/ft).} \]

Values of \( C_S \) are determined using Table 2.4 depending on road ditch side slope.

<table>
<thead>
<tr>
<th>Side Slope</th>
<th>( C_{ditch} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>4:1</td>
<td>291</td>
</tr>
<tr>
<td>3.5:1</td>
<td>341</td>
</tr>
<tr>
<td>3:1</td>
<td>399</td>
</tr>
<tr>
<td>2.5:1</td>
<td>467</td>
</tr>
<tr>
<td>2:1</td>
<td>549</td>
</tr>
<tr>
<td>1.5:1</td>
<td>659</td>
</tr>
<tr>
<td>1:1</td>
<td>808</td>
</tr>
<tr>
<td>0.75:1</td>
<td>916</td>
</tr>
<tr>
<td>0.5:1</td>
<td>1067</td>
</tr>
</tbody>
</table>

Secondary Road Erosion Estimate

- Assume 30-ft Right of Way
- Estimate longitudinal slope of road ditch from 0.1 to 5%
- Estimate ditch side slopes of 1:1 to 3:1
- For the site, determine \( R \) and \( K \)
- Apply Equation 2.2

ERODES Spreadsheet: download software from NCDOT Roadside Field Operations Downloads:

www.ncdot.org/doh/operations/dp_chief_eng/roadside/fieldops/downloads
**Example: Secondary Road Erosion**

Estimate erosion volume from a 2-acre secondary roadway construction during June-July in Carteret County with Goldsboro soil. The road ditch has a slope of 0.05 ft/ft and 2:1 side slopes.

Figures 2.1 and 2.2: Annual R = 340, and Carteret County is in Region 117
Table 2.1: During June-July, partial-year R = (0.14 + 0.23) (340) = 126
Table 2.2: K value is 0.24 (assume B Horizon – subsoil)
Table 2.4: C_{ditch} is 549 for 2:1 ditch side slopes
V_{ditch} = (549) (126) (0.24) (0.05) = 830 ft³/ac (Jun-Jul)
Total erosion for 2 acres = (830) (2) = 1,660 ft³ (Jun-Jul)
To convert to cubic yards: Erosion = 1,660 / 27 = 61 cubic yards (Jun-Jul)

---

**Example: Secondary Road Erosion**

Estimate erosion volume from a 1.5-acre secondary roadway construction during September-October in Halifax County with Rains soil. The road ditch has a slope of 0.02 ft/ft and 3:1 side slopes.

Figures 2.1 and 2.2: Annual R = 270, and Halifax County is in Region 117
Table 2.1: During Sep-Oct, partial-year R = (0.15 + 0.06) (270) = 57
Table 2.2: K value is 0.24 (assume B Horizon – subsoil)
Table 2.4: C_{ditch} is 399 for 3:1 ditch side slopes
V_{ditch} = (399) (57) (0.24) (0.02) = 109 ft³/ac (Sep-Oct)
Total erosion for 1.5 acres = (109) (1.5) = 164 ft³ (Sep-Oct)
To convert to cubic yards: Erosion = 164 / 27 = 6.1 cubic yards (Sep-Oct)
Worksheet

2.1. Estimate erosion from a 5-acre site in Wilmington during June-October with Cowee soil. The site is 800 ft long with elevation drop of 24 ft.

Average slope = 24 / 800 = 0.03 ft/ft (3% slope)
Figure 2.1 & 2.2: Annual R value is 350 and Region 117
Partial-year R = (0.14+0.23+0.20+0.15+0.06) (350) = 273
Table 2.2: K value is 0.28 (assume B Horizon – subsoil)
Figure 2.3: LS value is 1.1 (slope length = 800 ft; slope = 3%)
Table 2.3: CP value is 1.0 (assume loose surface with no cover)
Erosion per acre = (273) (0.28) (1.1) (1.0) = 84.1 tons/acre (Jun-Oct)
Total erosion for 5 acres = (84.1) (5) = 420 tons (Jun-Oct)

Worksheet

2.2. Estimate erosion volume from a 2-acre secondary roadway construction during September-October in Catawba County with Helena soil. The road ditch has a slope of 0.02 ft/ft and 1.5:1 side slopes.

Figures 2.1 & 2.2: Annual R = 180, and Region is 116
Table 2.1: Sep-Oct, partial-year R = (0.11 + 0.05) (180) = 29
Table 2.2: K value is 0.28 (assume B Horizon – subsoil)
Table 2.4: C_{ditch} is 659 for 1.5:1 ditch side slopes
V_{ditch} = (659) (29) (0.28) (0.02) = 107 ft³/ac (Sep-Oct)
Total erosion for 2 acres = (107) (2) = 214 ft³ (Sep-Oct)
To convert to cubic yards: Erosion = 214 / 27 = 8 cubic yards (Sep-Oct)
MODULE 3. Regulatory Issues

1. NC Sediment Pollution Control Act (1973)
2. NPDES: NCG01 General Stormwater Permit
3. Jurisdictional Areas - Conditions and Restrictions
   • US Army Corps of Engineers
   • NC DEQ Division of Water Resources
4. Environmentally Sensitive Area (ESA) & Riparian Buffers
5. Reclamation Plans: Staging, Borrow, Waste

NCDOT Roadside Environmental Unit Soil and Water Section:
http://ncdot.gov/doh/operations/dp%5Fchief%5Feng/roadside/soil%5Fwater/special_provisions/
NC Sediment Pollution Control Act (SPCA) Mandatory Standards

1. E&SC plan must be submitted 30 days prior to disturbance for areas greater than or equal to 1 acre
2. Land disturbing activity must be conducted in accordance with approved E&SC Plan
3. Establish sufficient buffer zone between work zone and water courses
4. Provide groundcover on slopes within 21 calendar days after any phase of grading (NCG-01 takes precedence)
5. The angle of cut and fill slopes shall be no greater than sufficient for proper stabilization

NPDES Program: NCG010000 (NCG01)

General Permit for Construction Activities, developed to meet federal NPDES requirements for activities disturbing > 1 acre

NCDEQ, Division of Water Resources delegated by EPA the authority to administer the program in North Carolina

The Erosion and Sedimentation Control plan contains the core requirements of the NPDES permit, but NCG01 has additional requirements.
### NCG010000 (NCG01)

<table>
<thead>
<tr>
<th>Site Area Description</th>
<th>Time Frame</th>
<th>Stabilization Time Frame Exceptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perimeter dikes, swales, ditches and slopes</td>
<td>7 days</td>
<td>None</td>
</tr>
<tr>
<td>High Quality Water (HQW) Zones</td>
<td>7 days</td>
<td>None</td>
</tr>
<tr>
<td>Slopes steeper than 3:1</td>
<td>7 days</td>
<td>If slopes are 10 ft or less in length and are not steeper than 2:1, then 14 days are allowed</td>
</tr>
<tr>
<td>Slopes 3:1 or flatter</td>
<td>14 days</td>
<td>7-days for slopes greater than 50 feet in length</td>
</tr>
<tr>
<td>All other areas with slopes flatter than 4:1</td>
<td>14 days</td>
<td>None (except for perimeters and HQW Zones)</td>
</tr>
</tbody>
</table>

### NCG010000 (NCG01)

**Surface Dewatering Devices**

Basins with drainage area 1 acre or larger must utilize a surface dewatering device in basins that discharge from the project
Regulated Jurisdictional Areas

- Streams
- Wetlands
- Rivers
- Riparian Buffers
- Lakes
- Reservoirs
- Endangered Species

Wetlands and Waterways: US Army Corps of Engineers (USACE)

- Section 404 of CWA permit require for effects on:
  - Wetlands & Surface waterways
- Practical alternatives
- Mitigation requirements
- Other laws: (e.g. Endangered Species, National Preservation Act)
Environmentally Sensitive Areas

- Neuse River Basin
- Tar-Pamlico River Basin
- Randleman Dam Watershed
- **Main Stem** of Catawba River
- Goose Creek Watershed (Yadkin/Pee-Dee Basin)
- Falls Lake (Nutrient Rules)
- Jordan Lake (Buffer Rules)
- High Quality Waters
- Trout Waters
- Others TBD
Buffer Requirements
(NC DEQ Division of Water Resources)

Riparian Buffer: vegetated land at edge of stream or lake
(50 feet or more)

DWR Permits specify:
– Mitigatable Impacts to Zone 1 (closest to stream)
– Mitigatable Impacts to Zone 2
– Allowable Impacts to Zone 1
– Allowable Impacts to Zone 2

Riparian Buffer

Vegetated land at edge of stream or lake that filters sediment, removes nutrients, and provides habitats

Usually referenced to the top of bank.
Central Coastal Plain Capacity Use Area (CCPCUA)

- Includes 15 Eastern counties: Beaufort, Carteret, Craven, Duplin, Edgecombe, Greene, Jones, Lenoir, Martin, Onslow, Pamlico, Pitt, Washington, Wayne, Wilson

- Annual registration and reporting of withdrawals is required for surface and ground water users of more than 10,000 GPD

- Permits are required for ground water users of more than 100,000 GPD

Reclamation Plans for Offsite Staging, Borrow, Waste Areas

Land disturbing activities associated with project that exceed project limits:
- Staging areas: might not need a plan
- Waste stockpiles (permanent or temporary)
- Borrow sites: newly-created pit must have dewatering basin
Staging Areas

Temporary areas, beyond project limits, utilized during the pursuit of a contract, to store equipment, materials, supplies, or other activities related to project

• Require environmental evaluation only if
  – No erodible material
  – No land disturbing activities
• Require full reclamation plan if contain
  – Erodible material (EM)
  – Land disturbing activities (LDA)
• Exempt if no EM & LDA and located at “existing facilities”
  – Unless jurisdiction features are present
• Overnight parking of equipment related to mobile operations are exempt

Reclamation Plan

• Reclamation Plan required for all sites regardless of size
• Approved by DOT Lead Engineer
• Elements of a Reclamation Plan:
  – Reclamation Plan form
  – Vicinity Map
  – Signatures
  – Environmental Evaluation
  – State Historical Preservation Office (SHPO) Letter
  – E&SC Plan with adequately designed measures
  – Seeding specifications
  – 1-year post final review
Reclamation E&SC Plan for Borrow Pits

• Site visit: Confirm all setbacks & haul road locations

• E&SC Plan:
  Above Water Table: Collect runoff and settle sediment
  < 1 acres: Temporary Rock Sediment Dam - Type B
  up to 10 acres: Skimmer Basin
  Below Water Table: Borrow Pit Dewatering Basin

• Closure plan:
  – Establish all final grades
  – Plan to replace all stockpiled topsoil and other overburden
  – Plan to establish permanent vegetation on disturbed areas

During Construction

• Delineate buffer zones
• Install EC devices as per approved E&SC Plan
• Excavate/Build slopes in manner that allows for seeding of slopes
• Stage seed slopes
• Monitor the turbidity of Borrow Pit discharge
• Sites are considered “single source”, unless the site has commercial status
Turbidity

Measure of water clarity: Higher turbidity tends to occur with more silt & clay particles suspended in water

Measured by passing light through a small sample and measuring the light dispersion

Nephelometric Turbidity Units (NTUs)

No standard for runoff yet

Turbidity Limits

<table>
<thead>
<tr>
<th>Surface Water Classification</th>
<th>Turbidity Not to Exceed Limit* (NTUs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Streams</td>
<td>50</td>
</tr>
<tr>
<td>Lakes &amp; Reservoirs</td>
<td>25</td>
</tr>
<tr>
<td>Trout Waters</td>
<td>10</td>
</tr>
</tbody>
</table>

*If turbidity exceeds these levels due to natural background conditions, the existing turbidity level cannot be increased*
* If turbidity exceeds NTU standard due to natural background conditions (upstream sample), the existing turbidity level cannot be increased.
Final Acceptance

• Borrow and Waste Sites must meet all the requirements of the Reclamation Plan

• Permanent stand of vegetation must cover the site

• Property owner will be notified that the site is complete and that inspections and possible repair work may occur during the coming year

• Site will be reviewed after 1 year and released if the site is deemed stable
## MODULE 4. Open Channel Design

Table 4.1. NCDOT guidelines for selecting channel linings.

<table>
<thead>
<tr>
<th>Channel Slope (%)</th>
<th>Recommended Channel Lining</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 1.5</td>
<td>Seed and Mulch</td>
</tr>
<tr>
<td>1.5 to 4.0</td>
<td>Temporary Liners (RECP)</td>
</tr>
<tr>
<td>&gt; 4.0</td>
<td>Turf Reinforced Mats or Hard</td>
</tr>
</tbody>
</table>

Temporary Liners: Rolled Erosion Control Products

- **Jute**
- **Coir**
- **Excelsior**
Selecting a Channel Lining

\[ \tau = (\gamma) (d_{\text{chan}}) (S_{\text{chan}}) \]  

(Equation 4.1)

- \( \tau \): average tractive force acting on the channel lining (lbs/ft²)
- \( \gamma \): unit weight of water, assumed to be 62.4 lbs/ft³
- \( d_{\text{chan}} \): depth of flow in the channel (ft)
- \( S_{\text{chan}} \): slope of the channel (ft/ft)

Select a channel lining that will resist the tractive force.

**Example:** Select a lining for a ditch with channel slope of 0.02 ft/ft and flow depth of 0.8 ft. NCDOT guidelines (Table 4.1) recommend temporary liner.

\[ \tau = (62.4 \text{ lb/ft}^3) (0.8 \text{ ft}) (0.02 \text{ ft/ft}) = 1.0 \text{ lb/ft}^2 \]

Table 4.3 (pg 23): Select a RECP with allowable tractive force > 1.0 lb/ft²
Examples: Channel Lining

Example: Select a suitable channel liner for a triangular ditch with maximum depth of 1 ft and slope of 1%.
Table 4.1: NCDOT guidelines for 1% slope allow seed and mulch or RECP Equation 4.1: \[ \tau = (62.4 \text{ lbs/ft}^3) (1 \text{ ft}) (0.01 \text{ ft/ft}) = 0.6 \text{ lbs/ft}^2 \] Table 4.3: Apply seed and mulch or select a RECP channel lining with a maximum allowable tractive force greater than 0.6 lbs/ft².

Example: Select a suitable channel liner for a triangular ditch with maximum depth of 2 ft and slope of 5%.
Table 4.1: NCDOT guidelines for 5% slope require a TRM or hard liner. Equation 4.1: \[ \tau = (62.4 \text{ lbs/ft}^3) (2 \text{ ft}) (0.05 \text{ ft/ft}) = 6.2 \text{ lbs/ft}^2 \] Table 4.3: Select a TRM channel lining with a maximum allowable tractive force greater than 6.2 lbs/ft².

Worksheet

4.1. Select a suitable channel liner for a triangular ditch with maximum depth of 1.2 ft and slope of 4.2%.
Table 4.1: NCDOT guidelines for >4% slope require TRM. Equation 4.1: \[ \tau = (62.4 \text{ lbs/ft}^3) (1.2 \text{ ft}) (0.042 \text{ ft/ft}) = 3.14 \text{ lbs/ft}^2 \] Table 4.3: Select a TRM channel lining with a maximum allowable tractive force greater than 3.14 lbs/ft² (N. American Green P550)
MODULE 5. Sediment Retention BMPs for NCDOT

1. Selection & Design Considerations
2. BMP Design Criteria
3. Example Specs and Calculations

NCDOT Roadside Environmental Unit Soil and Water Section:
http://ncdot.gov/doh/operations/dp%5Fchief%5Feng/roadside/soil%5Fwater/

<table>
<thead>
<tr>
<th>Table 1. BMP Selection</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BMP</strong></td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>T. Rock Sed. Dam A</td>
</tr>
<tr>
<td>T. Rock Sed. Dam B</td>
</tr>
<tr>
<td><strong>Silt Basin</strong></td>
</tr>
<tr>
<td>Skimmer basin</td>
</tr>
<tr>
<td>Infiltration basin</td>
</tr>
<tr>
<td>Near Pathline-perforated (tree w/ skimmer)</td>
</tr>
<tr>
<td>Stabilization Basin/Planted</td>
</tr>
<tr>
<td>So. Stabilization Basin/Planted</td>
</tr>
<tr>
<td>Rock Pipe Inlet Sed. Trap A</td>
</tr>
<tr>
<td>Rock Pipe Inlet Sed. Trap B</td>
</tr>
<tr>
<td>Stage Drift w/Flex</td>
</tr>
<tr>
<td>Rock Inlet Sed. Trap A</td>
</tr>
<tr>
<td>Rock Inlet Sed. Trap B</td>
</tr>
<tr>
<td>Rock Inlet Sed. Trap C</td>
</tr>
<tr>
<td><strong>S. Rock Silt Check A</strong></td>
</tr>
<tr>
<td><strong>S. Rock Silt Check B</strong></td>
</tr>
<tr>
<td><strong>Temporary Earth Berm</strong></td>
</tr>
<tr>
<td><strong>Temporary Silt Fence</strong></td>
</tr>
<tr>
<td><strong>Sediment Control Fence</strong></td>
</tr>
<tr>
<td><strong>Temporary Silt Silt</strong></td>
</tr>
<tr>
<td><strong>Temporary Diversion</strong></td>
</tr>
<tr>
<td><strong>Clean Water Diversion</strong></td>
</tr>
<tr>
<td><strong>Construction Excavation</strong></td>
</tr>
<tr>
<td><strong>Safety Fence</strong></td>
</tr>
<tr>
<td><strong>Sewer Pit Dewatering Basin</strong></td>
</tr>
<tr>
<td><strong>Walls/Attic Fiber Walls</strong></td>
</tr>
<tr>
<td><strong>Silt Check A with Walking and PAM</strong></td>
</tr>
</tbody>
</table>

Contributing land slope
Structure Sizing

*Two Criteria: (see Table 1)*

1. Minimum **Volume** (ft³) based on **disturbed** acres
2. Minimum **Surface Area** (ft²) based on **total** acres

Use Q₁₀ for normal design
Use Q₂₅ for Environmentally Sensitive Areas, Upper Neuse River Basin, Jordan Lake

<table>
<thead>
<tr>
<th>Device Outlet Type</th>
<th>Minimum Volume (ft³)</th>
<th>Minimum Surface Area (ft²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weir</td>
<td>3600 ft³/ac</td>
<td>435 Q₁₀ or Q₂₅</td>
</tr>
<tr>
<td>Surface Outlet</td>
<td>1800 ft³/ac</td>
<td>325 Q₁₀ or Q₂₅</td>
</tr>
<tr>
<td>Surface Outlet + Riser</td>
<td>1800 ft³/ac</td>
<td>435 Q₁₀ or Q₂₅</td>
</tr>
</tbody>
</table>

**Examples: Sizing BMPs**

*Example:* Calculate minimum volume and surface area for a skimmer basin serving a 6-acre construction site (all disturbed) with Q₁₀ = 20 cfs.

Volume: \[ V_{basin} \geq 1,800 \text{ ft}^3 \text{ per acre of disturbed land} \]
\[ V_{basin} \geq 1,800 \text{ ft}^3/\text{ac} (6 \text{ ac}) = 10,800 \text{ ft}^3 \]

Surface Area: \[ A_{basin} \geq 325 Q_{10} \text{ (skimmer = surface outlet)} \]
\[ A_{basin} \geq 325 (20) = 6,500 \text{ ft}^2 \]

*Example:* Calculate minimum volume and surface area for a Temporary Rock Sediment Dam Type B serving a 1-acre construction site (all disturbed) with Q₁₀ = 7 cfs.

Volume: \[ V_{basin} \geq 3,600 \text{ ft}^3 \text{ per acre of disturbed land} \]
\[ V_{basin} \geq 3,600 \text{ ft}^3/\text{ac} (1 \text{ ac}) = 3,600 \text{ ft}^3 \]

Surface Area: \[ A_{basin} \geq 435 Q_{10} \]
\[ A_{basin} \geq 435 (7) = 3,045 \text{ ft}^2 \]
### Length to Width (L:W) Ratio

<table>
<thead>
<tr>
<th>Ratio</th>
<th>Diagram</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2:1</td>
<td><img src="image" alt="Diagram" /></td>
<td>As L:W ratio increases, basin length increases and width decreases. Equal surface areas are depicted at left.</td>
</tr>
<tr>
<td>3:1</td>
<td><img src="image" alt="Diagram" /></td>
<td></td>
</tr>
<tr>
<td>4:1</td>
<td><img src="image" alt="Diagram" /></td>
<td></td>
</tr>
<tr>
<td>5:1</td>
<td><img src="image" alt="Diagram" /></td>
<td></td>
</tr>
</tbody>
</table>

### Porous Baffle Spacing

Baffles required in Silt Basins at drainage turnouts, Type A and B Temporary Rock Sediment Dams, Skimmer Basins, Stilling Basins:

- **3 baffles** evenly-spaced if basin length > 20 ft
- **2 baffles** evenly-spaced if basin length 10 - 20 ft
- **1 baffle** if basin length ≤ 10 ft (State Forces)
Weir Length for Spillway

**Skimmers and Infiltration Basins:**

Weir Length = $\frac{Q_{\text{peak}}}{0.4}$

**Temporary Sediment Dam - Type B:**

Minimum 4ft for 1 acre or less
Temporary Rock Sediment Dam, Type B

Drainage area < 1 ac
Surface Area = 435Q_{10} or 435Q_{25}
Volume = 3600 ft³/ac
Coir Baffles
Minimum Weir Length = 4 ft for 1 acre or less
L:W ratio 2:1 to 5:1

Skimmer Basin

Drainage area < 10 ac
Surface Area = 325Q_{10} or 325Q_{25}
Volume = 1800 ft³/ac disturbed
Depth = 3 ft at weir
Coir Baffles (3)
L:W ratio 2:1 to 6:1
Sideslopes 1.5:1 max.
Dam height <= 5 ft
Faircloth Skimmer (surface outlet)

Designed to captures 90% of fine (silts & clay) sediment when water is held for 24 hours

Rock Pipe Inlet Sediment Trap, Type A

Drainage area < 1 ac
Volume = 3600 ft³/ac
Pipe inlet no greater than 36 in
Dam height = 18 inches
Class B stone lined with sediment control stone
Locate > 30 ft from travel lane
Check Dam & Wattle Spacing

On NCDOT projects:

Coastal Plain: Spacing = 600 / slope (%)  
Example: For 2% slope, space checks 300 ft apart  

Piedmont and West: Spacing = 300 / slope (%)  
Example: For 3% slope, space checks 100 ft apart

Infiltration Basin

Drainage area < 10 ac  
Surface Area = 325Q_{10} or 325Q_{25}  
Volume = 1800 ft³/ac  
Depth = 3 ft at weir  
Coir Baffles (1-3)  
L:W ratio 3:1 to 5:1  
Must dewater in 3 days or less  
Soil permeability must be at least 0.5 in/hr  
(from NRCS B or C soil horizon, slowest rate)
Guidelines for Infiltration Basins

- Locate in Coastal Plain
- Locate in fill slope with Temporary Silt Ditch bringing runoff
- Do NOT locate in “Soils Prone to Flooding”
- Do not locate in cut ditches

Soils Prone to Flooding (Examples)

- Wake
  - Buncombe (BuB)
  - Chewacla (CmA)
  - Congaree (CoA)
  - Congaree (CpA)
  - Wehadkee (WnA)
  - Wehadkee and Bibb (WoA)
  - Wehadkee (WpA)
- Martin
  - Bibb (Bb)
  - Chastain (Ch)
  - Dorovan (Do)
  - Roanoke (Ro)
- Richmond
  - Chewacla (ChA)
  - Johnston (JmA)
- New Hanover
  - Dorovan (Do)
  - Johnston (JO)
  - Pamlico (Pm)
  - Bohicket (TM)
- Hoke
  - Chewacla (Ch)
  - Johnston (JT)
- Dare
  - Carteret (CeA)
  - Currituck (CuA)
  - Hobonny (HoA)
Design Steps for Basins, Sediment Dams, & Traps

1. Minimum volume and surface area
2. Width and length at the weir/spillway height based on sideslopes
3. Emergency spillway weir length
4. Baffle spacing

Example: Temp Rock Sediment Dam Type B

Disturbed area = 1 ac; $Q_{10} = 2.5$ cfs
Interior sideslopes = 1.5:1; $L:W = 3:1$

1. **Minimum Volume and Surface Area:**
   - Minimum Volume = $3600 \times 1 \text{ ac} = 3600 \text{ ft}^3$
   - Minimum Surface Area = $435 \times Q_{10} = 435 \times 2.5 \text{ cfs} = 1088 \text{ ft}^2$
   - Depth = Volume / Area = $3600 \text{ ft}^3 / 1088 \text{ ft}^2 = 3.3 \text{ ft}$
   - For DOT projects, Design Depth = 2 to 3 ft
   - Therefore, use depth = 3 ft
   - Adjusted Minimum Area = Volume / depth = $3600 / 3 = 1200 \text{ ft}^2$

Surface area must be greater to account for sideslopes
**Example: Temp Rock Sed Dam Type B**

2. **Width and depth at top and base (trial & error):**

Start with area = 1,200 ft² and a 3:1 length to width ratio

Trial Width, \( W_{\text{top}} = \sqrt{\frac{A}{\text{L to W ratio}}} = \sqrt{\frac{1200}{3}} = 20 \text{ ft} \)

To account for sideslopes, add to top width (try 3 ft):

Trial \( W_{\text{top}} = 20 + 3 = 23 \text{ ft} \)

Trial \( L_{\text{top}} = 3 \times W_{\text{top}} = 3 \times 23 = 69 \text{ ft} \)
**Example: Temp Rock Sed Dam Type B**

Calculate base width and base length using 1.5 to 1 sideslopes:

\[
W_{\text{base}} = W_{\text{top}} - (\text{depth} \times 1.5 \times 2 \text{ sides}) = 23 - (3 \times 1.5 \times 2) = 14 \text{ ft}
\]

\[
L_{\text{base}} = L_{\text{top}} - (\text{depth} \times 1.5 \times 2 \text{ sides}) = 69 - (3 \times 1.5 \times 2) = 60 \text{ ft}
\]

---

**Example: Temp Rock Sed Dam Type B**

Calculate volume (minimum required = 3,600 ft³):

\[
\text{Volume} = \frac{d}{3} \left[ W_{\text{top}} L_{\text{top}} + W_{\text{base}} L_{\text{base}} + \left( \frac{W_{\text{top}} L_{\text{base}} + W_{\text{base}} L_{\text{top}}}{2} \right) \right]
\]

\[
\text{Volume} = \frac{3}{3} \left[ 23 \times 69 + 14 \times 60 + \left( \frac{23 \times 60 + 14 \times 69}{2} \right) \right]
\]

Volume = 3600 ft³ (meets minimum requirement)

Surface Area (at weir elevation) = 23 x 69 = 1587 ft²
**Example: Temp Rock Sed Dam Type B**

**Principal spillway:**

Water exits the basin via the Class B stone dam covered with sediment control stone

**Rock weir:**

Weir must be sized according to weir chart based on total drainage area (1 acre)

Weir Length (1 acre) = 4 ft

**Baffles:**

Since basin is 69 ft long, use 3 baffles spaced evenly. Divided the basin into 4 quarters, each 17 ft long
Design Steps: Skimmer Basin with Baffles

1. Minimum volume and surface area
2. Width and length based on sideslopes
3. Dewatering flow rate (top 2 ft in 3 days)
4. Skimmer size and orifice diameter
5. Primary spillway barrel pipe size
6. Emergency spillway weir length
7. Baffle spacing

Skimmer Basin on Mitchell Mill Rd
Skimmer Basin on Wade Ave.

Example: Skimmer Basin with Baffles

Disturbed area = 9.9 ac; $Q_{10} = 17$ cfs; Dewater time = 3 days; Interior sideslopes = 1.5:1; L:W = 3:1

1. Minimum Volume and Surface Area:

Minimum Volume = 1800 x 9.9 acres = 17,820 ft³
Minimum Surface Area = $325Q_{10} = 325 \times 17$ cfs = 5,525 ft²
Depth = Volume / Area = $\frac{17,820}{5,525} = 3.2$ ft

For DOT projects, Design Depth = 3 ft
Therefore, adjust minimum surface area up:

$Area_{min} = Volume / Design \text{ Depth} = \frac{17,820}{3} = 5,940$ ft²

Surface area must be greater to account for sideslopes
Example: Skimmer Basin with Baffles

2. Width and length at top and base (trial & error):

Start with area = 5,940 ft² and a 3 to 1 length to width ratio

\[
\text{Trial Width, } W_{\text{top}} = \sqrt{\frac{A}{L \text{ to } W \text{ ratio}}} = \sqrt{\frac{5940}{3}} = 45 \text{ ft}
\]

To account for sideslopes, add to top width (try 3 ft):

\[
\begin{align*}
\text{Trial } W_{\text{top}} & = 45 + 3 = 48 \text{ ft} \\
\text{Trial } L_{\text{top}} & = 3 \times W_{\text{top}} = 3 \times 48 = 144 \text{ ft}
\end{align*}
\]
**Example: Skimmer Basin with Baffles**

Calculate base width and base length using 1.5 to 1 sideslopes:

\[
W_{\text{base}} = W_{\text{top}} - (\text{depth} \times 1.5 \times 2 \text{ sides}) = 48 - (3 \times 1.5 \times 2) = 39 \text{ ft}
\]

\[
L_{\text{base}} = L_{\text{top}} - (\text{depth} \times 1.5 \times 2 \text{ sides}) = 144 - (3 \times 1.5 \times 2) = 135 \text{ ft}
\]

Calculate volume (minimum required = 17,820 ft\(^3\)):

\[
\text{Volume} = \frac{d}{3} \left[ W_{\text{top}} L_{\text{top}} + W_{\text{base}} L_{\text{base}} + \left( \frac{W_{\text{top}} L_{\text{base}} + W_{\text{base}} L_{\text{top}}}{2} \right) \right]
\]

\[
\text{Volume} = \frac{3}{3} \left[ (48)(144) + (39)(135) + \left( \frac{(48)(135) + (39)(144)}{2} \right) \right]
\]

Volume = 18,225 ft\(^3\) (meets minimum requirement)

Surface Area (at weir elevation) = 48 x 144 = 6,912 ft\(^2\)
**Example: Skimmer Basin with Baffles**

3. **Dewatering flow rate (top 2 ft in 3 days)**

Calculate width & length at depth =1 ft using 1.5:1 sideslopes:

\[ W_{1ft} = W_{top} - (\text{depth} \times 1.5 \times 2 \text{ sides}) = 48 - (2 \times 1.5 \times 2) = 42 \text{ ft} \]

\[ L_{1ft} = L_{top} - (\text{depth} \times 1.5 \times 2 \text{ sides}) = 144 - (2 \times 1.5 \times 2) = 138 \text{ ft} \]

Calculate volume in the top 2 ft

\[
\text{Volume} = \frac{d}{3} \left[ W_{top} L_{top} + W_{1ft} L_{1ft} + \left( \frac{W_{top} L_{1ft} + W_{1ft} L_{top}}{2} \right) \right]
\]

\[
\text{Volume} = \frac{2}{3} \left[ (48)(144) + (42)(138) + \left( \frac{(48)(138) + (42)(144)}{2} \right) \right]
\]

Volume in top 2 ft = 12,696 ft³
Example: Skimmer Basin with Baffles

4. Select Faircloth Skimmer to dewater top 2 ft in 3 days

Volume in top 2 ft, \(V_{\text{skim}} = 12,696 \text{ ft}^3\)

Dewater Rate, \(Q_{\text{skim}} = \frac{V_{\text{skim}}}{t_{\text{dewater}}} = \frac{12,696}{3} = 4,232 \text{ ft}^3/\text{day}\)

Select the Skimmer Size to carry at least 4,232 ft³/day

From Table 5.1, a 2.5-inch skimmer carries 6,234 ft³/day with driving head, \(H_{\text{skim}} = 0.208 \text{ ft}\)

Why not use a 2-inch skimmer?

Select skimmer based on flow rate, Table 5.1

<table>
<thead>
<tr>
<th>Skimmer Diameter (inches)</th>
<th>(Q_{\text{skimmer}}) Max Outflow Rate (ft³ / day)</th>
<th>(H_{\text{skimmer}}) Driving Head (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5</td>
<td>1,728</td>
<td>0.125</td>
</tr>
<tr>
<td>2.0</td>
<td>3,283</td>
<td>0.167</td>
</tr>
<tr>
<td>2.5</td>
<td>6,234</td>
<td>0.208</td>
</tr>
<tr>
<td>3.0</td>
<td>9,774</td>
<td>0.250</td>
</tr>
<tr>
<td>4.0</td>
<td>20,109</td>
<td>0.333</td>
</tr>
<tr>
<td>5.0</td>
<td>32,832</td>
<td>0.333</td>
</tr>
<tr>
<td>6.0</td>
<td>51,840</td>
<td>0.417</td>
</tr>
<tr>
<td>8.0</td>
<td>97,978</td>
<td>0.500</td>
</tr>
</tbody>
</table>

* Updated 2007: www.fairclothskimmer.com
Orifice Diameter for Skimmer

\[ D_{\text{orifice}} = \sqrt[3]{\frac{Q_{\text{skim}}}{2310 \sqrt{H_{\text{skim}}}}} \]  

(Equation 5.2)

- \( D_{\text{orifice}} \) = diameter of the skimmer orifice in inches (in)
- \( Q_{\text{skimmer}} \) = basin outflow rate in cubic feet per day (ft\(^3\)/day)
- \( H_{\text{skimmer}} \) = driving head at the skimmer orifice from Table 5.1 in feet (ft)

\[ D_{\text{orifice}} = \sqrt[3]{\frac{4,232}{2,310 \sqrt{0.208}}} = 2.0 \text{ inches} \]

The orifice in the knockout plug is drilled to a 2-inch diameter.

Example: Skimmer Basin with Baffles

5. Primary spillway barrel pipe size using \( Q_{\text{skim}} = 4,232 \)

NCDOT: Use smooth pipe on 1% slope (minimum 4-inch)

Figure 4.1: At 1% slope, a 4-inch pipe carries up to 100 gpm = 19,300 ft\(^3\)/day

6. Emergency spillway weir length:

NCDOT: \( L_{\text{weir}} = 17 \text{ cfs}/0.4 = 42.5 \text{ ft or 43 ft} \)
Example: Skimmer Basin with Baffles

7. Baffle Spacing:

For $L_{\text{top}} > 20$ ft, use 3 baffles to divide into 4 chambers:

Baffle spacing = $L_{\text{top}} / 4 = 144 / 4 = 36$ ft
**Worksheet 5.1. Infiltration Basin**

Infiltration basin on Rains soil (permeability= 0.5 in/hr) with drainage area of 8 acres?

Drainage area = 8 ac; permeability = 0.5 in/hr

For NCDOT maximum depth = 3ft

**Dewatering time** = 3ft x hr/0.5 in x 12 in/ft = 72 hr or 3 days

**Design volume** = 1800 x 8 = 14,400 ft³

*NCDOT guidelines: drains in 3 days, drainage area <10ac., soil permeability at least 0.5 in/hr

---

**Worksheet 5.2. Temp Rock Sed Dam Type B**

Disturbed area = 0.9 ac; $Q_{10} = 3$ cfs;

Interior sideslopes = 1.5:1; $L:W = 3:1$

1. **Minimum Volume and Surface Area:**

Minimum Volume = 3600 x 0.9 ac = 3240 ft³

Minimum Surface Area = $435 Q_{10} = 435 \times 3$ cfs = 1305 ft²

Depth = Volume / Area = 3240 ft³ / 1305 ft² = 2.5 ft

For DOT projects, **Design Depth = 2 to 3 ft**

Therefore, use depth = 2.5 ft

Surface area must be greater to account for sideslopes
2. Width and depth at top and base (trial & error):
Start with area = 1305 ft\(^2\) and a 3:1 length to width ratio

\[
\text{Trial Width, } W_{\text{top}} = \sqrt{\frac{A}{\text{L to W ratio}}} = \sqrt{\frac{1305}{3}} = 21 \text{ ft}
\]

To account for sideslopes, add to top width (try 3 ft):

\[
\text{Trial } W_{\text{top}} = 21 + 3 = 24 \text{ ft}
\]
\[
\text{Trial } L_{\text{top}} = 3 \times W_{\text{top}} = 3 \times 24 = 72 \text{ ft}
\]

Worksheet 5.2. Temp Rock Sed Dam Type B

Calculate base width and base length using 1.5 to 1 sideslopes:

\[
W_{\text{base}} = W_{\text{top}} - (\text{depth} \times 1.5 \times 2 \text{ sides}) = 24 - (2.5 \times 1.5 \times 2) = 16.5 \text{ ft}
\]
\[
L_{\text{base}} = L_{\text{top}} - (\text{depth} \times 1.5 \times 2 \text{ sides}) = 72 - (2.5 \times 1.5 \times 2) = 64.5 \text{ ft}
\]
Worksheet 5.2. Temp Rock Sed Dam Type B

Calculate volume (minimum required = 3,240 ft³):

\[
\text{Volume} = \frac{d}{3} \left[ W_{\text{top}} L_{\text{top}} + W_{\text{base}} L_{\text{base}} + \left( \frac{W_{\text{top}} L_{\text{base}} + W_{\text{base}} L_{\text{top}}}{2} \right) \right]
\]

\[
\text{Volume} = \frac{2.5}{3} \left[ (24)(72) + (16.5)(64.5) + \left( \frac{(24)(64.5) + (16.5)(72)}{2} \right) \right]
\]

Volume = 3448 ft³ (meets minimum requirement)

Surface Area (at weir elevation) = 24 x 72 = 1728 ft²
**Worksheet 5.2. Temp Rock Sed Dam Type B**

Principal spillway:

Water exits the basin via the Class B stone dam covered with sediment control stone

Rock weir:

Weir must be sized according to the weir chart based on total drainage area (1 acre)

Weir Length (1 acre) = 4 ft

Baffles:

Since basin is 72 ft long, use 3 baffles spaced evenly.
Divided the basin into 4 quarters, each 18 ft long

---

**Worksheet 5.3. Skimmer Basin**

*Design:* For a 5.5-acre construction site with $Q_{10} = 12$ cfs, design a basin to be dewatered in 3 days. Use 1.5:1 interior sideslopes and 3:1 length:width ratio.

1. Minimum volume and surface area
2. Width and length based on sideslopes
3. Dewatering flow rate (top 2 ft in 3 days)
4. Skimmer size and orifice diameter
5. Primary spillway barrel pipe size
6. Emergency spillway weir length
7. Baffle spacing
Worksheet 5.3. Skimmer Basin

**Design:** For a 5.5-acre construction site with $Q_{10} = 12$ cfs, design a basin to be dewatered in 3 days. Use 1.5:1 interior sideslopes and 3:1 length:width ratio.

1. **Minimum Volume and Surface Area:**

   Minimum Volume = $1800 \times 5.5 \text{ acres} = 9,900 \text{ ft}^3$

   Minimum Surface Area = $325Q_{10} = 325 \times 12 \text{ cfs} = 3,900 \text{ ft}^2$

   Depth = Volume / Area = $9,900 \text{ ft}^3 / 3,900 \text{ ft}^2 = 2.5 \text{ ft}$

   For DOT projects, **Design Depth = 3 ft**

   Surface area must be greater to account for sideslopes

2. **Width and Length at top and base (trial & error):**

   Start with area = $3,900 \text{ ft}^2$ and a 3:1 length:width ratio

   
   \[
   \text{Trial Width, } W_{\text{top}} = \sqrt{\frac{A}{L \text{ to } W \text{ ratio}}} = \sqrt{\frac{3,900}{3}} = 36.1 \text{ ft}
   \]

   Trial Width, $W_{\text{top}} = 37 \text{ ft}$ round up, 36ft doesn’t work

   Trial Length, $L_{\text{top}} = 3 \times 37 = 111 \text{ ft}$

   Try this width and length with 1.5:1 sideslopes to check if volume > $9,900 \text{ ft}^3$
Worksheet 5.3. Skimmer Basin

Calculate base width and base length using 1.5 to 1 sideslopes:

\[ W_{\text{base}} = W_{\text{top}} - (\text{depth} \times 1.5 \times 2 \text{ sides}) = 37 - (3 \times 1.5 \times 2) = 28 \text{ ft} \]

\[ L_{\text{base}} = L_{\text{top}} - (\text{depth} \times 1.5 \times 2 \text{ sides}) = 111 - (3 \times 1.5 \times 2) = 102 \text{ ft} \]

For 3ft \( W_{\text{base}} = 30 \text{ ft}; W_{\text{top}} = 39 \text{ ft}; L_{\text{top}} = 117 \text{ ft}; L_{\text{base}} = 108 \text{ ft} \)

Worksheet 5.3. Skimmer Basin

Calculate volume (minimum required = 9,900 ft\(^3\)):

\[
\text{Volume} = \frac{d}{3} \left[ W_{\text{top}} L_{\text{top}} + W_{\text{base}} L_{\text{base}} + \left( \frac{W_{\text{top}} L_{\text{base}} + W_{\text{base}} L_{\text{top}}}{2} \right) \right]
\]

\[
\text{Volume} = \frac{3}{3} \left[ (37)(111) + (28)(102) + \left( \frac{(37)(102) + (28)(111)}{2} \right) \right]
\]

\[
\text{Volume} = 10,404 \text{ ft}^3 \quad \text{(meets minimum requirement)}
\]

trial add 3ft Vol. = 11,664 ft\(^3\)

Surface Area (at weir elevation) = 37 x 111 = 4,107 ft\(^2\)

3ft trial Area = 4563 ft\(^2\)
Worksheet 5.3. Skimmer Basin

3. Dewatering flow rate (top 2 ft in 3 days)

Calculate width & length at depth =1 ft using 1.5:1 sideslopes:

\[ W_{1\text{ft}} = W_{\text{top}} - (\text{depth} \times 1.5 \times 2 \text{ sides}) = 37 - (2 \times 1.5 \times 2) = 31 \text{ ft} \]

\[ L_{1\text{ft}} = L_{\text{top}} - (\text{depth} \times 1.5 \times 2 \text{ sides}) = 111 - (2 \times 1.5 \times 2) = 105 \text{ ft} \]

Calculate volume in the top 2 ft

\[
\begin{align*}
\text{Volume} &= \frac{d}{3} \left[ W_{\text{top}} L_{\text{top}} + W_{1\text{ft}} L_{1\text{ft}} + \left( \frac{W_{\text{top}} L_{1\text{ft}} + W_{1\text{ft}} L_{\text{top}}}{2} \right) \right] \\
\text{Volume} &= \frac{2}{3} \left[ (37)(111) + (31)(105) + \left( \frac{(37)(105) + (31)(111)}{2} \right) \right] \\
\text{Volume in top 2 ft} &= 7,350 \text{ ft}^3
\end{align*}
\]
Worksheet 5.3. Skimmer Basin

4. Select Faircloth Skimmer to dewater top 2 ft in 3 days

Volume in top 2 ft, \( V_{\text{skim}} = 7,350 \text{ ft}^3 \)

Daily \( Q_{\text{skim}} = \frac{7,350}{3} = 2,450 \text{ ft}^3 / \text{day} \)

Select the Skimmer Size to carry at least 2,450 ft\(^3\)/day

From Table 5.1, a 2-inch skimmer carries 3,283 ft\(^3\)/day with driving head, \( H_{\text{skim}} = 0.167 \text{ ft} \)

\[
D_{\text{orifice}} = \sqrt{\frac{Q_{\text{skim}}}{2310H_{\text{skim}}}} = \sqrt{\frac{2,450}{2,310 \times 0.167}} = 1.6 \text{ inches}
\]

The orifice in the knockout plug is drilled to a 1.6-inch diameter.

Select skimmer based on flow rate, Table 5.1

<table>
<thead>
<tr>
<th>Skimmer Diameter (inches)</th>
<th>( Q_{\text{skimmer}} ) Max Outflow Rate (ft(^3) / day) *</th>
<th>( H_{\text{skimmer}} ) Driving Head (ft) *</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5</td>
<td>1,728</td>
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<td>0.333</td>
</tr>
<tr>
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<td>51,840</td>
<td>0.417</td>
</tr>
<tr>
<td>8.0</td>
<td>97,978</td>
<td>0.500</td>
</tr>
</tbody>
</table>

* Updated 2007: www.fairclothskimmer.com
**Worksheet 5.3. Skimmer Basin**

5. Primary spillway barrel pipe size using $Q_{\text{skim}} = 2,450$

NCDOT: Use smooth pipe on 1% slope (minimum 4-inch)

Figure 4.1 (Pipe Chart): At 1% slope, a 4-inch pipe carries up to 100 gpm = 19,300 ft$^3$/day

6. Emergency spillway weir length:

NCDOT: $L_{\text{weir}} = 12 \text{ cfs}/0.4 = 30 \text{ ft}$

7. Baffle Spacing:

Baffle spacing = $L_{\text{top}} / 4 = 111 / 4 = 28 \text{ ft}$

---

**MODULE 6: Below Water Table Borrow Pits Dewatering Options**

**Tier I Methods**
- Borrow Pit Dewatering Basin
- Land Application (Irrigation)
- Geotextile Bags
- Alum
- Gypsum
- Polyacrylamide (PAM)

**Tier II Methods [rare & unique resources]**
- Well Point Pumping
- Impoundments
- Cell Mining
- Sand Media Filtration
- Wet Mining
Borrow Pit Dewatering Basin

- Basin at pump outlet to settle sediment
- No area requirement
- Volume = pump rate x detention time:
  - Detention time = 2 hours minimum
  - \( V_{\text{still}} = 16(Q_{\text{still}}) \)  \( Q = \) pump rate in gpm
  - Max pump rate = 1,000 gpm (2.2 cfs)
- Maximum depth = 3 ft
- Earthen embankments are fill above grade
- L:W = 2:1 minimum
- Surface outlet:
  - Non-perforated riser pipe (12-inch)
  - Flashboard riser

Turbidity Reduction: PAM at 1 mg/L in stilling basin

**Powder**: mix 1 pound of PAM per 100 gallons of water

Figure 6.1: At \( Q_{\text{still}} = 1000 \) gpm, inject liquid PAM mix at 1.3 gpm

Inject mix at pump intake (suction line) or just after water leaves pump

**Floc-Log**: turbulent flow 60-80 gpm inside corrugated plastic pipe (no inner liner)
Figure 6.1. PAM Injection (liquid mix)

<table>
<thead>
<tr>
<th>PAM Injection Rate (gpm)</th>
<th>Pump Rate (gpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>0.5</td>
</tr>
<tr>
<td>0.5</td>
<td>1.0</td>
</tr>
<tr>
<td>1.0</td>
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</tr>
<tr>
<td>3.0</td>
<td>3.5</td>
</tr>
<tr>
<td>3.5</td>
<td>4.0</td>
</tr>
</tbody>
</table>

- Pump Rate = 1000 gpm
- Pam Inject = 1.3 gpm
- Pump Rate = 1 MGD
- Pam Inject = 0.9 gpm

1 MGD = 695 gpm

Example: Borrow Pit Dewatering Basin

Design a Borrow Pit Dewatering Basin with 2-hour detention time, PAM injection, and pumping rate, \( Q_{\text{still}} = 300 \text{ gpm} \).

Volume: \( V_{\text{still}} = 16 (Q_{\text{still}}) \) \quad \text{(Equation 6.1, pg 34)}

\[
V_{\text{still}} = 16 (300 \text{ gpm}) = 4,800 \text{ ft}^3
\]

For depth = 3 ft, minimum surface area:

\[
\text{Area} = \frac{\text{Volume}}{\text{Depth}} = \frac{4,800 \text{ ft}^3}{3 \text{ ft}} = 1,600 \text{ ft}^2
\]
**Example: Borrow Pit Dewatering Basin**

**Width and length at top and base (trial & error):**

Start with area = 1,600 ft² and a 2:1 length to width ratio

\[
\text{Trial Width, } W_{\text{top}} = \sqrt{\frac{A}{\text{L to W ratio}}} = \sqrt{\frac{1,600}{2}} = 29 \text{ ft}
\]

To account for sideslopes, add to top width (try 4 ft):

\[
\text{Trial } W_{\text{top}} = 29 + 4 = 33 \text{ ft}
\]

\[
\text{Trial } L_{\text{top}} = 2 \times W_{\text{top}} = 2 \times 33 = 66 \text{ ft}
\]

**Example: Borrow Pit Dewatering Basin**

Calculate base width and base length using 1.5 to 1 sideslopes:

\[
W_{\text{base}} = W_{\text{top}} - (\text{depth} \times 1.5 \times 2 \text{ sides}) = 33 - (3 \times 1.5 \times 2) = 24 \text{ ft}
\]

\[
L_{\text{base}} = L_{\text{top}} - (\text{depth} \times 1.5 \times 2 \text{ sides}) = 66 - (3 \times 1.5 \times 2) = 57 \text{ ft}
\]
**Example: Borrow Pit Dewatering Basin**

Calculate volume (minimum required = 4,824 ft³):

\[
\text{Volume} = \frac{d}{3} \left[ W_{\text{top}} L_{\text{top}} + W_{\text{base}} L_{\text{base}} + \left( \frac{W_{\text{top}} L_{\text{base}} + W_{\text{base}} L_{\text{top}}}{2} \right) \right]
\]

\[
\text{Volume} = \frac{3}{3} \left[ (33)(66) + (24)(57) + \left( \frac{(33)(57) + (24)(66)}{2} \right) \right]
\]

Volume = 5,300 ft³ (meets minimum requirement)

Surface Area (at weir elevation) = 33 x 66 = 2,200 ft²

---

**Example: Borrow Pit Dewatering Basin**

**Spillway Options:**

- Riser Pipe (12-inch diameter) with invert at 3 ft depth
- Flashboard Riser with invert at 3 ft depth and flow rate of 300 gpm (0.67 cfs)

**PAM Injection:**

Mix 1 pound of PAM powder per 100 gallons of water

Figure 6.1: \(Q_{\text{still}} = 300 \text{ gpm}\), inject liquid PAM mix at 0.4 gpm

Inject mix at pump intake (suction line) or just after water leaves pump
Worksheet 6.1: Borrow Pit Dewatering Basin

Design a Borrow Pit Dewatering Basin with (1.5:1 sideslopes; 2:1 L:W ratio) 2-hour detention, PAM injection, and pumping rate, $Q_{\text{still}} = 1 \text{ MGD} = 695 \text{ gpm}$.

Volume: $V_{\text{still}} = 16 \times (Q_{\text{still}})$ \hspace{1cm} (Equation 6.1)

$V_{\text{still}} = 16 \times 695 \text{ gpm} = 11,120 \text{ ft}^3$

For depth = 3 ft, minimum surface area:

Area = Volume/Depth = $11,120 \text{ ft}^3 / 3 \text{ ft} = 3,700 \text{ ft}^2$

Worksheet 6.1: Borrow Pit Dewatering Basin

Width and length at top and base (trial & error):

Start with area = $3,700 \text{ ft}^2$ and a 2:1 length to width ratio

Trial Width, $W_{\text{top}} = \sqrt{\frac{A}{\text{L to W ratio}}} = \sqrt{\frac{3,700}{2}} = 43.0 \text{ ft}$

To account for sideslopes, add to top width (try 4 ft):

Trial $W_{\text{top}} = 43 + 4 = 47 \text{ ft}$

Trial $L_{\text{top}} = 2 \times W_{\text{top}} = 2 \times 47 = 94 \text{ ft}$
Worksheet 6.1: Borrow Pit Dewatering Basin

Calculate base width and base length using 1.5 to 1 sideslopes:

\[
W_{\text{base}} = W_{\text{top}} - (\text{depth} \times 1.5 \times 2 \times \text{sides}) = 47 - (3 \times 1.5 \times 2) = 38 \text{ ft}
\]

\[
L_{\text{base}} = L_{\text{top}} - (\text{depth} \times 1.5 \times 2 \times \text{sides}) = 94 - (3 \times 1.5 \times 2) = 88 \text{ ft}
\]

Worksheet 6.1: Borrow Pit Dewatering Basin

Calculate volume (minimum required = 11,120 ft\(^3\)):

\[
\begin{align*}
\text{Volume} & = \frac{d}{3} \left[ W_{\text{top}} L_{\text{top}} + W_{\text{base}} L_{\text{base}} + \left( \frac{W_{\text{top}} L_{\text{base}} + W_{\text{base}} L_{\text{top}}}{2} \right) \right] \\
& = \frac{3}{3} \left[ (47)(94) + (38)(85) + \left( \frac{(47)(85) + (38)(94)}{2} \right) \right]
\end{align*}
\]

Volume = 11,432 ft\(^3\) \(\) (meets minimum requirement)

Surface Area (at weir elevation) = 47 \times 94 = 4,418 ft\(^2\)
Worksheet 6.1: Borrow Pit Dewatering Basin

Spillway Options:
- Riser Pipe (12-inch diameter) with invert at 3 ft depth
- Flashboard Riser with invert at 3 ft depth and flow rate of 695 gpm (1.6 cfs)

PAM Injection:
Mix 1 pound of PAM powder per 100 gallons of water

Figure 6.1: $Q_{\text{still}} = 695$ gpm, inject liquid PAM mix at 0.9 gpm
Inject mix at pump intake (suction line) or just after water leaves pump

Below Water Table Sites: Wetland Protection

Type 1: Flow from wetland to pit
Type 2: Flow from pit to wetland
  - Does not require Skaggs Method calculations
  - Minimum 25 ft buffer (setback) from wetland
  - Minimum 50 ft buffer from stream
Type 3: Flow-through pits: wetland to pit on one side, pit to wetland on other side

For Types 1 & 3 or uncertain flow direction:
- 400 ft buffer OR
- Skaggs Method calculations
Skaggs Method: Determine Setback

Wetland hydrology is defined as an area where the water table is normally within 1.0 ft of the soil surface for a continuous critical duration, defined as 5-12.5% of the growing season. The 5% was used in the Skaggs method.

Calculate “Lateral Effect,” or setback, x

$$d_0 = h_0 - d$$

**Soil Characteristics:**
- Effective hydraulic conductivity, $$K_e$$ (Soil Survey or site investigation)
- Drainable porosity, $$f = 0.035$$ for DOT applications

**Surface Depressional Storage:**
- 1 inch if area is relatively smooth
- 2 inches if area is rough with shallow depressions

**Depth to water table at borrow pit:** $$d_0 = 2 \text{ ft}$$

**Depth of soil profile to restrictive layer:** $$h_0$$
Effective Hydraulic Conductivity

\[ K_e = \frac{K_1 d_1 + K_2 d_2 + K_3 d_3}{d_1 + d_2 + d_3} \]

\[ K_e = \frac{1.2(3.5) + 3.7(8.4) + 7.1(1.5)}{3.5 + 8.4 + 1.5} = 3.4 \text{ ft} / \text{d} \]

Surface Storage

- Natural Forest or Pocosin: Surface storage = 2 in
- Land planed agricultural field: Surface storage = 1 in
Skaggs Method: Determine Setback

\( h_0 = \) average profile depth to restrictive layer (measured from wetland soil surface)

\( d_0 = 2 \text{ ft} \) = depth from wetland soil surface to water in the borrow pit (\( d_0 = h_0 - d \)). For NCDOT, \( d_0 = 2 \text{ ft} \)

\( d \) = depth of pit water to restrictive layer, \( d = h_0 - 2 \text{ ft} \)
Skaggs Method: Determine Setback

Table 6.1 based on County climate data:

- 30+ years of rainfall data & ET estimates
- DRAINMOD simulates how water table changes during growing season for depressional storage
- Select depressional storage (1 or 2 inches)

**For NCDOT, use 2 ft ‘depth to water’ (d_o = 2 ft)**

Note: reference section (pg 35) contains details on the method and the background to the method.

\[ H = \frac{h}{h_0} = \frac{(h_0 - 0.83)}{h_0} \]
\[ D = \frac{d}{h_0} = \frac{(h_0 - 2)}{h_0} \]
Skaggs Method Software
www.ncdot.org/doh/Operations/dp_chief_eng/roadside/fieldops/downloads/

Inputs:
- Soil type (information only)
- County
- Depth from wetland surface to water in pit ($d_o = 2$ ft, NCDOT)
- Surface depressional storage (1 inch smooth, 2 inches rough)
- Depth from wetland soil surface to restrictive layer, $h_o$
- Drainable porosity of the soil, $f=0.035$ for NCDOT
- Effective Hydraulic Conductivity of each soil layer between pit and wetland, $K_e$, inches per hour

Example: Skaggs Method

The wetland is located in Johnston County on a Rains soil. From wetland soil surface to impermeable/restrictive layer is 15 ft. Soil hydraulic conductivity is 4 ft/day. The wetland has a natural rough surface. What is the minimum lateral setback?
Do = depth to pit water surface (NCDOT=2 ft)
Ho = depth from wetland soil surface to restrictive layer

5% of growing season

Hydraulic conductivity 
= \frac{4 \text{ ft/day} \times 12 \text{ in/ft} \times \text{day/24 hr}}{24 \text{ hr}} = 2 \text{ in/hr}
Worksheet 6.2. Skaggs Method Software Input

For a borrow pit in Pitt County with Emporia soil (K = 6 ft/day), depth from wetland soil surface to the impermeable layer is 10 ft, ground surface of wetland area is smooth, fill in the inputs for the Skaggs Method software program.

Ditch Depth = 2 ft
Surface = 1 in
Do=10 ft
Porosity =0.035
Hydraulic conductivity = 6 ft/day * 12 in/ft * day/24 hr = 3 in/hr