Sedimentation Controls
Predicting Their Performance

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IECA President
Past President SCIECA
Past Chair IECA Sediment Control Products and Standards Committee
Past Chair Science Based Sediment Control Design Methodology Committee

Learning isn’t just about acquiring new skills and knowledge; it’s also about shaking up our stale assumptions and misguided preconceptions.
Why Predict Their Performance

- Historically
  - Start with a plan that meets the permit requirements and modify it as the plans failures become apparent.

- Future
  - Start with a plan that will meet performance based requirements.

- Results
  - Better protection of the environment
  - Reduced cost
  - Better relations between regulated and regulators
Current Sedimentation Control Design

- If the control fails
  - get rid of it.

- Add more of it.

“It ain’t so much the things we don’t know that get us into trouble. It’s the things we do know that just ain’t so” *Artemus Ward*
Predict the Performance

- Understand what is happening at the control.
  - We have sediment laden water entering the control.
  - We should have ponding of the runoff.
  - Sedimentation will be occurring if we have ponding.
  - Most likely runoff will be exiting the control.
Water & Soil

- Add soil to a jar
- Add water to the soil
- Close lid tightly
- Shake jar
- Observe jar
- Conclusions
Sedimentation

What is the one thing that we can look to that will give us a conclusive prediction of the effectiveness of a sedimentation control?

Time
Effects of Time

- When runoff is detained a sufficient amount of time the sediment will settle out of the storm water runoff and will not exist the site.
- If the runoff exits the control prior to the required settling time, sediment will exit the control with the runoff.
I think they need a little more time.
How Much Time

- What determines the amount of time that the runoff will need to be detained?

Soil Type
Soil Type Classification
Soil

- Sand: 38 seconds = 1 foot
- Silt: 33 minutes = 1 foot
- Clay: 230 days = 1 foot
Stoke’s Law

<table>
<thead>
<tr>
<th>Material</th>
<th>Diameter (mm)</th>
<th>Hydraulic subsiding value (mm/sec)</th>
<th>Time required to settle 1 ft.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravel</td>
<td>10.0</td>
<td>1000.0</td>
<td>0.3 sec</td>
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<tr>
<td>Coarse sand</td>
<td>1.0</td>
<td>100.0</td>
<td>3.0 sec</td>
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<tr>
<td>Fine sand</td>
<td>0.1</td>
<td>8.0</td>
<td>38.0 sec</td>
</tr>
<tr>
<td>Silt</td>
<td>0.01</td>
<td>0.154</td>
<td>33.0 min</td>
</tr>
<tr>
<td>Bacteria</td>
<td>0.001</td>
<td>0.00154</td>
<td>55.0 hr</td>
</tr>
<tr>
<td>Clay</td>
<td>0.00001</td>
<td>0.0000154</td>
<td>230.0 days</td>
</tr>
<tr>
<td>colloidal particles</td>
<td>0.000001</td>
<td>0.0000000154</td>
<td>63 years</td>
</tr>
</tbody>
</table>
# Soil

<table>
<thead>
<tr>
<th>Soil</th>
<th>Foot/</th>
<th>Seconds</th>
<th>Minutes</th>
<th>Hours</th>
<th>Days</th>
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</thead>
<tbody>
<tr>
<td>Sand</td>
<td>1</td>
<td>38</td>
<td>0.6333</td>
<td>0.010556</td>
<td>0.000439815</td>
</tr>
<tr>
<td>Silt</td>
<td>1</td>
<td>1980</td>
<td>33</td>
<td>0.5</td>
<td>0.022916667</td>
</tr>
<tr>
<td>Clay</td>
<td>1</td>
<td>19,872,000</td>
<td>331,200</td>
<td>5,220</td>
<td>230</td>
</tr>
</tbody>
</table>
What Do We Know So Far

- Time is the key
  - Provide enough time and you can remove the sediment.
- The time required is determined by soil type.
  - If we know our soil type we can determine how long the control needs to pool the water to remove the sediment.
- Every control drainage area will have a unique soil type.
- Every control will have a unique amount of time that will be required for the control to achieve the required performance standard.
Detain not Retain
Designing the Control

- Assume: silt soil type
  - We need to retain the runoff 33 minutes (1980 seconds)
- Assume: Flow rate of 2 cfs (cubic feet per second).
  - $2 \text{ cfs} \times 1980 \text{ seconds} = \text{Required Capacity of 3960 cf}$
- For the control to retain the runoff for 33 minutes (1980 seconds) the control must form a pool with a minimum storage volume of 3960 cf.
Detain not Retain

Time = \frac{\text{Volume}}{\text{Flow rate}}

\begin{align*}
\text{Volume} &= 3,960 \text{ cf} \\
\text{Flow rate} &= 2 \text{ cfs} \\
\text{Time} &= 1,980 \text{ seconds}
\end{align*}
What Do We Know So Far

- Time is the key
  - Provide enough time and you can remove the sediment.
- The sedimentation time required is determined by soil type.
- Each control will have a unique soil type therefore each control will have a unique required sedimentation time.
- Flow rate will determine the time it will take to fill the sedimentation pool based on the pool volume of the control.
How to Predict Flow Rate

- There are several storm water runoff models
  - TR-55
  - Rational Method
  - HEC1
  - DETPOND
- Make sure the model is the correct model for your site conditions.
Flow Rates

- What determines the flow rate to the control
  - Geographic location
  - Topography
  - Soil type
- These are conditions that we normally cannot control so we must design for these conditions.
- Every control location will have a unique flow rate.
Flow Rate Changes Detention Time

104 cfs → 3,960 cf → 104 cfs

38 seconds
Flow Rate Changes Detention Time

2 cfs → 1,980 seconds → 2 cfs

3,960 cf

- 2 cfs
- 3,960 cf
- 2 cfs
Flow Rate Changes Detention Time

0.0002 cfs 19,800,000 seconds 0.0002 cfs

3,960 cf

0.0002 cfs

3,960 cf
Change the Flow Change the Results

<table>
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Evaluating Performance

- Assume soil type: SAND
  - We need to retain the runoff 0.63 minutes (38 seconds)
- Assume: Flow rate of 45 cfs (cubic feet per second)
- Assume: Storage volume of 1710 cf
- Capacity of 1710 cf / 45 cfs = 38 seconds

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<td>1980</td>
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</tbody>
</table>
Evaluating Performance

- Assume soil type: **SILT**
- We need to retain the runoff 33 minutes (1980 seconds)
- Assume: Flow rate of **45** cfs (cubic feet per second)
- Assume: Storage volume of **1710** cf
- Capacity of **1710** cf / **45** cfs = **38** seconds

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</table>
Evaluating Performance

- Assume soil type: **Silt**
- We need to retain the runoff 33 minutes (1980 seconds)
- Assume: Flow rate of 0.86 cfs (cubic feet per second)
- Assume: Storage volume of 1710 cf
- Capacity of 1710 cf / 0.86 cfs = 1980 seconds

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What Do We Know So Far

- Time is the key
  - Provide enough time and you can remove the sediment.
- The sedimentation time required is determined by soil type.
- Each control will have a unique soil type therefore each control will have a unique require sedimentation time
- Each control will have a unique flow rate.
- Most of the time we have no control over the soil type and flow rate.
What We Can Control

- The design of the control
  - We can control the storage volume of the control.
  - We control the amount of time provided for sedimentation.
  - We control the success of failure of the control.
Predicting Performance

- Assume soil type: SAND
- We need to retain the runoff 0.63 minutes (38 seconds)
- Assume: Flow rate of 2 cfs (cubic feet per second).
- 38 seconds x 2 cfs = Required Capacity of 76 cf
- For the control to pond the runoff for 0.63 minutes (38 seconds) the control must form a pool with a minimum storage volume of 76 cf.

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</tbody>
</table>
Predicting Performance

- Assume soil type: **SILT**
  - We need to retain the runoff 33 minutes (1980 seconds)
- Assume: Flow rate of **2 cfs** (cubic feet per second).
- **1980 seconds x 2 cfs** = Required Capacity of **3960 cf**
- For the control to pond the runoff for 33 minutes (1980 seconds) the control must form a pool with a minimum storage volume of **3960 cf**.

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<td>1980</td>
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<td>Clay</td>
<td>19,872,000</td>
</tr>
</tbody>
</table>
Predicting Performance

- Assume soil type: **CLAY**
- We need to retain the runoff 230 days (19,872,000 seconds)
- Assume: Flow rate of 2 cfs (cubic feet per second).
- $19,872,000 \times 2 \text{ cfs} = \text{Required Capacity of } 39,744,000 \text{ cf}$
- For the control to pond the runoff for (230 days) the control must form a pool with a minimum storage volume of 39,744,000 cf.

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<td>19,872,000</td>
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</tbody>
</table>
Current Permit vs. ELGs

- Current permit
  - “Erosion and sediment controls must be designed to retain sediment on-site to the extent practicable with consideration for local topography, soil type, and rainfall.”

- ELGs
  - No consideration for on-site conditions. No gray area of “to the extent practicable”
  - Meet the required standard. ??? NTU (Nephelometric Turbidity Units)
The Problem With Soil

- Sand, Silt, and Clay
  - Most of the time it has all three in it.
  - Clay being the biggest challenge for sedimentation control design.
  - Most of the time we cannot control what type of soil is on the site.
  - Sometimes the soil changes.
NRCS Soil Map

- Natural Resource Conservation Service (NRCS)
  - Website address
Soils Report

Map Unit Legend

<table>
<thead>
<tr>
<th>Map Unit Symbol</th>
<th>Map Unit Name</th>
<th>Acres in AOI</th>
<th>Percent of AOI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Aledo association, undulating</td>
<td>2.8</td>
<td>100.0%</td>
</tr>
<tr>
<td>2</td>
<td>Altoga silty clay, 3 to 5 percent slopes</td>
<td>2.8</td>
<td>104.4%</td>
</tr>
<tr>
<td>9</td>
<td>Bastill fine sandy loam, 1 to 3 percent slopes</td>
<td>0.0</td>
<td>0.0%</td>
</tr>
<tr>
<td>55</td>
<td>Medlin-Sanger clay, 5 to 15 percent slopes</td>
<td>14.1</td>
<td>51.1%</td>
</tr>
<tr>
<td>67</td>
<td>Sanger clay, 1 to 3 percent slopes</td>
<td>0.5</td>
<td>2.3%</td>
</tr>
<tr>
<td>89</td>
<td>Sanger clay, 3 to 5 percent slopes</td>
<td>7.3</td>
<td>26.2%</td>
</tr>
<tr>
<td><strong>Totals for Area of Interest</strong></td>
<td></td>
<td><strong>27.6</strong></td>
<td><strong>100.0%</strong></td>
</tr>
</tbody>
</table>
### Sand, Silt, and Clay

#### Report—RUSLE2 Related Attributes

<table>
<thead>
<tr>
<th>RUSLE2 Related Attributes—Denton County, Texas</th>
<th>Pct. of map unit</th>
<th>Slope length (ft)</th>
<th>Hydrologic group</th>
<th>Kf</th>
<th>T factor</th>
<th>% Sand</th>
<th>% Silt</th>
<th>% Clay</th>
</tr>
</thead>
<tbody>
<tr>
<td>1—Aledo association, undulating</td>
<td>100</td>
<td>161</td>
<td>D</td>
<td>.32</td>
<td>1</td>
<td>34.7</td>
<td>37.8</td>
<td>27.5</td>
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<tr>
<td>Aledo</td>
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<tr>
<td>2—Altoga silty clay, 3 to 5 percent slopes</td>
<td>100</td>
<td>180</td>
<td>B</td>
<td>.32</td>
<td>5</td>
<td>7.2</td>
<td>47.8</td>
<td>45.0</td>
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<td>Altoga</td>
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<tr>
<td>9—Bastis fine sandy loam, 1 to 3 percent slopes</td>
<td>100</td>
<td>298</td>
<td>B</td>
<td>.24</td>
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<td>56—Medlin-Sanger clay, 5 to 15 percent slopes</td>
<td>60</td>
<td>121</td>
<td>D</td>
<td>.32</td>
<td>4</td>
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<tr>
<td>Medlin</td>
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<td>56—Medlin-Sanger clay, 5 to 15 percent slopes</td>
<td>30</td>
<td>125</td>
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<td>22.1</td>
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<tr>
<td>Sanger</td>
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<td>67—Sanger clay, 1 to 3 percent slopes</td>
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<td>D</td>
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<td>22.1</td>
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<tr>
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<td>68—Sanger clay, 3 to 5 percent slopes</td>
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<td>22.1</td>
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</tr>
</tbody>
</table>
Onsite Control Location

- Location of the control on the site
  - Determines the drainage area of the control
    - Soil type in the drainage area
      - Required sedimentation time
      - Amount of runoff draining to the control
    - Topography of the drainage area
      - Amount of runoff draining to the control
      - Volume of water detain by the control
Topography Make it Work for You
Topography Make it Work for You
Location and Topography
Location and Topography
Add More of It
Add More of It
Provide More Time
Height of the Control

12"
Height of the Control

24”
Height of the Control

8”
If the Control Design Works

- Sediment buildup can be the downfall of the control.
Design for Maintenance

- Predict the volume of water you need to pool.
- Predict the sediment volume.
- Provide a storage volume equal to or greater than the total of both.
MUSLE not RUSLE

- These models look at soil loss in different ways.
  - Universal Soil Loss Equation
  - Revised Universal Soil Loss Equation
  - Revised Universal soil loss Equation 1
  - Revised Universal Soil Loss Equation 2
    - Long term average soil erosion
  - Modified Universal Soil Loss Equation
    - Specific storm event’s sediment yield
Soil Type

- Effects
  - Required retention time
  - Flow rate
  - Sediment load
Geographic Location

- Effects
  - Flow rate
  - Sediment load
Topography

- Effects
  - Flow rate
  - Sediment load
  - Control configuration
If the Control Fails

- Blame the designer not the control.

- Add more time not just more of the control.