Smaller, Cheaper, Better: An Update on Advances in Limestone Treatment Technology

Presented at the 2016 West Branch Susquehanna Restoration Symposium

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Hedin Environmental
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Hedin Environmental

- small consulting firm based in Pittsburgh
- specialize in AMD assessments and passive treatment
- 60 installed passive treatment systems based on our designs
  - Most in Pennsylvania treating coal mine drainage
  - Internationally: Laos, Brazil, Tasmania, South Africa, Great Britain
Passive Treatment

Treatment philosophy that maximizes the use of natural biogeochemical processes, local materials, and gravity to treat mine water

Successful implementation results in treatment systems with lower maintenance costs than conventional treatment technologies
Design Process:

**Chemistry** determines technology:
- What **kind** of treatment components are needed
- What order should those components be arranged

**Loading** determines the sizing:
- How big does each component need to be
Characterize Mine Water

Net alkaline

- DO, Fe\(^{3+}\), Al all < 1 mg/L (high Fe\(^{2+}\))
  - Anoxic Limestone Drain
    - Net Alkaline
      - Ponds
        - Wetland
          - Mn
            - Oxic Limestone Bed
              - Mn

Net acid

- DO, Fe\(^{3+}\), Al any > 1 mg/L
  - High Fe\(^{2+}\)
    - Vertical Flow Pond
      - Ponds
        - Wetland
          - Mn
            - Oxic Limestone Bed
              - Mn

Final Discharge

Oxic Limestone Bed (drainable)

- DO, Fe\(^{3+}\), Al any > 1 mg/L
  - Fe < 10 mg/L
    - Repeat As Needed
      - Ponds
        - Wetland
          - Mn
            - Oxic Limestone Bed
              - Mn

Ponds
Limestone (calcite) use in passive systems

- Limestone dissolves to generate alkalinity
  \[ \text{CaCO}_3 + \text{H}^+ \rightarrow \text{HCO}_3^- + \text{Ca}^{2+} \]
- Sustaining limestone dissolution
  - Protect surfaces from armoring with solids
  - Protect aggregate from plugging with solids
  - Accomplish by flushing solids out of limestone bed
- Can install enough limestone to be effective for 20 years
Drainable Limestone Beds

Development of DLBs resulted from DEP innovative treatment technology grant (Final report 2008)
Mitchell West Box

- Constructed in 2007
- 30 tons of limestone in 30 CY roll off container
- 1 gpm since 2008
  - Average acidity loading of 76 g m\(^{-2}\) day\(^{-1}\) (Double typical VFP loading)
- \(~5.7\) tons of limestone dissolved (19%)

<table>
<thead>
<tr>
<th></th>
<th>Raw</th>
<th>DLB Out</th>
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</thead>
<tbody>
<tr>
<td>pH</td>
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<td>3</td>
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<td>8</td>
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<tr>
<td>Mn</td>
<td>13</td>
<td>3 (2.9)</td>
</tr>
</tbody>
</table>
Drainable Limestone Beds

The little dumpster that could

Effluent pH

Mitchell West Box

Jan-07 Jan-08 Jan-09 Jan-10 Jan-11 Jan-12 Jan-13 Jan-14 Jan-15 Jan-16 Jan-17
Drainable Limestone Beds

AMD

Oh, the humanity!!!!
Drainable Limestone Beds

Fe Accounting
- Fe out, 4%
- Fe retain, 25%

Mn Accounting
- Mn out, 25%
- Mn flush, 12%
- Mn retain, 62%

Al Accounting
- Al out, 3%
- Al flush, 62%
- Al retain, 62%
Sustainable!

- Majority of Fe and Al solids flushed out
- Theory: pore volume created by dissolving calcite makes more room for solids
  - Plugging unlikely – if calcite dissolution slows or stops, so does solids formation
  - Failure is indicated by a decline in effluent quality, not plugging
- Effectiveness can be restored by cleaning limestone
  - Every 3-10(?) years, depending on loading
  - Costs $2-$5 per ton
They’re Spreading!

- 13 installed systems to date
- 19 DLBs
- 27,000 tons total
Clinton County
Clinton County Conservation District
Constructed 2013
3 DLB systems
~3,600 total tons
## DLB Example – Muddy Run

<table>
<thead>
<tr>
<th></th>
<th>MR-2</th>
<th>MR-4</th>
<th>MR-6</th>
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<tr>
<td>Mn</td>
<td>13.3</td>
<td>7.0</td>
<td>5.0</td>
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DLB Example – Muddy Run

MR-6
1,100 tons

MR-4
700 tons

MR-2
1,800 tons

Muddy Run
1.3 miles
pH 4.5 -> 7.2
DLB Example – Fall Brook

Tioga County
TCCCC, TCCD, SWN, More!
Online November 2015
2 DLB systems
4 DLBs
~12,000 total tons
### North

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<tr>
<th></th>
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<tbody>
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<td>Flow</td>
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<tr>
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<tr>
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<tr>
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<tr>
<td>Mn</td>
<td>12.2</td>
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### South

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<tr>
<td>Mn</td>
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## DLB Example – Fall Brook

<table>
<thead>
<tr>
<th>Fall Brook</th>
<th>Pre</th>
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<tbody>
<tr>
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<tr>
<td>Acidity</td>
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<tr>
<td>Al</td>
<td>5.7</td>
<td>0.7</td>
</tr>
<tr>
<td>Fe</td>
<td>4.2</td>
<td>0.5</td>
</tr>
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</table>
DLB Example – Teerco

Teerco Site
- Permitted Mine Site
- Greene County
- Beazer East, Inc.
- Online early 2015
- 1 system, 4 DLBs
- 6,000 total tons
## DLB Example – Teerco

<table>
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<tr>
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<th>Raw</th>
<th>Final Out</th>
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<tbody>
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<tr>
<td>pH</td>
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<tr>
<td>Acidity</td>
<td>146</td>
<td>-91</td>
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<tr>
<td>Al</td>
<td>3.0</td>
<td>&gt;0.1</td>
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<tr>
<td>Fe</td>
<td>9.5</td>
<td>1.2</td>
</tr>
<tr>
<td>Mn</td>
<td>42</td>
<td>1.1</td>
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Summary

Drainable Limestone Beds
Watershed restoration
• Alkaline effluent with low metals
• Reliable
• Resilient
Compact footprint
• Fit where other technologies won’t
• Metals removal in one step
Permit compliance
• Mn removal
• Reliable
• Low maintenance
Questions?

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