Reducing Nonpoint Source Pollution through Effective Ditch Management

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Artificial Drainage in Delaware

- Engineered system to remove excess water
  - Ditches
  - Channelized streams
  - Tile drains

- Required for land use in many areas
  - Poorly drained soils
  - High water tables
Tax Ditch 101

- 1951 Drainage Law
- Governmental subdivision of the state
- Formed through Superior Court
- Powers related to maintenance of drainage
- Managed by elected landowners

234 Tax Ditch Organizations responsible for maintaining 2,000 miles of channel providing benefit to >100,000 people.
Concerns with Artificial Drainage

- Conduits for nutrient and sediment pollution
  - Eutrophication of Chesapeake and Delaware Inland Bays
- Accumulation of vegetation and sediment requires maintenance
- Impacts from current maintenance practices on water quality are unknown
Minor Maintenance Activities

- Deteriorated pipe replacements and clearing
- Beaver dam removal
- Annual mowing
- Weed wiper bar
  - Control woody vegetation
  - Maintain clear Rights-of-Way
Major Maintenance
Tax Ditch Dip Out

• Dredging of ditch
  – Performed as needed
    (15-20 years)

• Spoils placed on adjacent field and spread

• Variable timing between steps
  – Difficult to know nutrient loss from spoil and amended soils
Research Objectives

- Characterize adjacent field and spoils for potential loss prior to incorporation
- Determine potential P loss from spoil amended areas

**Goal**: Determine method to predict P loss from amended areas
7 of 15 tax-ditches scheduled for dip-out in 2013-2014 were selected

Only portion of ditch maintained at a time
- Segments ranged from 1.25-3.6 km (≈ 0.75-2.25 mile)

Land use in proximity to dip-out was mainly agricultural or forested
Soil Sampling

• Collected soils from adjacent fields prior to dip
• Collected representative spoil samples from piles placed on sampled fields
Laboratory Analysis

• Characterize field and spoil for potential loss prior to incorporation

• Simulate chisel plowing of field and corresponding spoil
  – Mix at 3 different ratios
    • (1S:7F, 3S:5F, and 7S:1F)
  – Determine and maintain field capacity of field-spoil mixtures
  – Collect and characterize subsamples at 2 time intervals (2 and 30 days)
Characterization of Field and Spoil

*Numbers above are M3-PSR values

**Average Mehlich 3 P Concentrations (mg kg⁻¹)**

- **Field Soils**
- **Spoil Sediments**
- **Agronomic Threshold**

**Ditch Site**

- 1A
- 1B
- 1C
- 2
- 3A
- 3B
- 4A
- 4B
- 5A
- 5B
- 6A
- 6B
- 7

Environmental Risk > 0.15

*Numbers above are M3-PSR values*
Characterization of Field and Spoil

Average Water Extractable P Concentrations (mg kg\(^{-1}\))

<table>
<thead>
<tr>
<th>Dich Site</th>
<th>Field Soils</th>
<th>Spoil Sediments</th>
<th>Environmental Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>1A</td>
<td>1.73</td>
<td>0.19</td>
<td>0.19</td>
</tr>
<tr>
<td>1B</td>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1C</td>
<td>5</td>
<td>0.19</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>1.57</td>
<td></td>
</tr>
<tr>
<td>3A</td>
<td>9</td>
<td>1.57</td>
<td></td>
</tr>
<tr>
<td>3B</td>
<td>11</td>
<td></td>
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</tr>
<tr>
<td>4A</td>
<td>4</td>
<td>2.37</td>
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<tr>
<td>4B</td>
<td>7</td>
<td>0.64</td>
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<tr>
<td>5A</td>
<td>4</td>
<td>0.32</td>
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<tr>
<td>5B</td>
<td>2</td>
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</tr>
<tr>
<td>6A</td>
<td>16</td>
<td>0.94</td>
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</tr>
<tr>
<td>6B</td>
<td>16</td>
<td>1.07</td>
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</tr>
<tr>
<td>7</td>
<td>5</td>
<td>0.19</td>
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</tr>
</tbody>
</table>

Environmental Risk: 0.19, 0.19, 1.57, 1.57, 0.46, 2.37, 0.64, 0.32, 0.19, 0.94, 1.07, 0.19
Amended Field Soils - 2 Day Results

Incorporation decreases Mehlich 3 P

- Field Soil
- 1S:7F
- 3S:5F
- 7S:1F
- Agronomic Threshold

Average Mehlich 3 P Concentrations (mg kg⁻¹)

Ditch Site

1A 1B 1C 2 3A 3B 4A 4B 5A 5B 6A 6B 7
Amended Field Soils- 30 Day Results

Average Mehlich 3 P Concentrations (mg kg⁻¹)

- Field Soils
- 1S:7F
- 3S:5F
- 7S:1F
- Agronomic Threshold

Ditch Site

1A 1B 1C 2 3A 3B 4A 4B 5A 5B 6A 6B 7
Amended Field Soils- 2 Day Results

Incorporation decreases Water Extractable P

- Field Soils
- 1S:7F
- 3S:5F
- 7S:1F
- Environmental Risk

Average Water Extractable P Concentrations (mg kg⁻¹)

Ditch Site:
1A 1B 1C 2 3A 3B 4A 4B 5A 5B 6A 6B 7
Amended Field Soils- 30 Day Results

- Average Water Extractable P Concentrations (mg kg⁻¹)

Legend:
- Field Soils
- 1S:7F
- 3S:5F
- 7S:1F
- Environmental Risk

Graph showing the concentration of P for different ditch sites labeled 1A to 7, with average values ranging from 0 to 18 mg kg⁻¹.
Incubation Conclusions

• Incorporation reduces potential risk of P loss from amended areas
  – More effective at reducing WEP than M3-P
  – Difference not always significant so need to determine optimum spreading depth

• Next steps:
  – Investigate properties of field and spoil samples to determine effective spreading depth for ditch sites
    • Regression analysis
  – Provide recommendation
Research Objectives and Goal

• Characterize ditch bottom sediments to determine potential release of P to overlying waters

• Quantify P removal from maintenance

**Overall Goal:** To provide a recommendation that improves current management
Ditch Core Sediment Sampling

Collect intact sediment core samples within each ditch 0-5, 5-15, 15+ cm
Characterization of Core Samples

• Characterize P in sediments
  – Water soluble P (WSP), Mehlich 3 P (M3-P), EPA_{3050}-P
  – Soil texture and sequential P fractionation

• Quantify P removal during maintenance
Ditch Core Sediments: Mehlich 3 P

- Generally Mehlich 3-P decreased with core sediment depth and following maintenance.
- 5-15cm sediments at times possessed greatest concentrations.
- Those sediments possessed 0-5cm sediments in excess of agronomic needs.
Ditch Core Sediments: Water Extractable P (WEP)
Ditch Core Sediments: Mehlich 3 Phosphorus Saturation Ratio

Average Mehlich 3 PSR Values

[Graph showing Mehlich 3 Phosphorus Saturation Ratio for different sediment layers (0-5cm, 5-15cm, 15+cm) and tax ditch systems/prongs (TYN-SM, CM-M, TYN-JM, MTZ-P7, GB-M, MB-P4, WO-M, BB-P2, MTZ-P3, POC-P2, GB-P5, GB-P3).]

Environmental Risk
Ditch Core Conclusions

• Enrichment of P in top 0-5cm sediments
  – Excessive levels observed
  – M3 PSR below environmental risk threshold but it is important to note that channel conditions are different than field

• Next steps:
  – Calculate total P removed from maintenance activity
  – Provide recommendation
Thank you for your time and attention.

Questions or Comments?