Coupling a Groundwater Model and Nitrogen Concentration Data at the UNH Organic Research Dairy Farm

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Location: UNH Organic Research Dairy Farm in Lee, NH

Project Objective: First phase is to measure all material and energy flows across the farm

Our Part: Characterize the hydrology (water budget / groundwater model)
LiDAR data: National Center for Airborne Laser Mapping (NCALM)
Hydrologic Monitoring

Records hydraulic head measurements every hour
West to East Cross-sectional View of the Back Field at the Burley-Demerrit Farm

- BD-15
- BD-14
- BD-12

Legend:
- Till
- Sand
- Clay
- Eliot Fm--Calcaceous quartzite and phyllite.
North-South Cross-sectional View at the Burley-Demerrit Farm

Legend:
- Clay
- Sand
- Till
- Eliot Fm – Calcaneous quartzite and phyllite.
Precipitation Rate (in/day)
Groundwater Elevations
Evapotranspiration
Calculated using Penman-Monteith
V-notch Weir
Parshall Flume
Streamflow at Watershed Outlet
Groundwater Contour Map:
Unconfined / Confined Aquifer

Lamprey River

Elevations in feet

Legend
- Wells
- Stream Gages

Unconfined Aquifer
Confined Aquifer
Development of Groundwater Model

• Objectives:
  1. Develop understanding of spatial distribution of groundwater recharge and factors that affect its magnitude
  2. Provide a platform for simulating solute fluxes
• Utilize near surface capabilities of MODFLOW 2005 (UZF Package)
Nitrate concentrations [mg/L]

Source: McDowell
<table>
<thead>
<tr>
<th>#</th>
<th>Description</th>
<th>Nitrogen (kg/yr)</th>
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</thead>
<tbody>
<tr>
<td><strong>INPUTS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Hay/Silage/Baleage</td>
<td>2060</td>
</tr>
<tr>
<td>2</td>
<td>Grain</td>
<td>1799</td>
</tr>
<tr>
<td>3</td>
<td>Feed Additives</td>
<td>796</td>
</tr>
<tr>
<td>4</td>
<td>Deposition</td>
<td>381</td>
</tr>
<tr>
<td><strong>INTERNAL</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Manure</td>
<td>6716</td>
</tr>
<tr>
<td>6</td>
<td>Hay/Silage/Baleage</td>
<td>1849</td>
</tr>
<tr>
<td>7</td>
<td>Forage</td>
<td>1256</td>
</tr>
<tr>
<td><strong>Outputs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Milk</td>
<td>997</td>
</tr>
</tbody>
</table>

Gabriel Perkins & John Aber
Point Sources of Nitrogen

1. Manure compost pile
2. Pig waste lagoon (abandoned)
3. Scrapings from barn & feed area
Nitrate concentrations [mg/L]

Source: McDowell
Simulated concentrations match those observed in wells fairly well. However, is manure loading rate ~200 kg N/ year unrealistic?

Quasi-steady state (t=10 years)

Nitrate as “conservative” solute – no decay

Simulated concentrations match those observed in wells fairly well.

However, is manure loading rate ~200 kg N/ year unrealistic?
Simulated Nitrate [mg/L]

Quasi-steady state (t=10 years)

Denitrification as a first order decay process ($k=0.3 \, \text{yr}^{-1}$)

More realistic loading rate of 2000 kg/N per year.

Simulated concentrations in wells are much higher than observed.
Nitrate concentrations [mg/L]

<table>
<thead>
<tr>
<th>Location</th>
<th>$^{15}\text{N}$</th>
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<tbody>
<tr>
<td>BD-3 (4)</td>
<td>15.70</td>
</tr>
<tr>
<td>BD-7</td>
<td>6.30</td>
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<tr>
<td>BD-8</td>
<td>14.56</td>
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<tr>
<td>BD-10</td>
<td>13.54</td>
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<tr>
<td>Tributary</td>
<td>16.90</td>
</tr>
<tr>
<td>Stream</td>
<td>16.20</td>
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</tbody>
</table>

Sources: B. McDowell, A. Hristov
Conclusions & Future Work

- Spatial distribution of recharge is strongly dependent on depth to water table and ability of plants to utilize groundwater for ET.
- Need to:
  1) upscale high resolution (space and time) groundwater model to simulate long-term solute fluxes and
  2) characterize winter and spring conditions
- Preliminary solute transport simulations suggest that the system takes ~ 10 years to reach steady state.
- Source characterization will be one important component of resolving occurrence and rate of denitrification.