Annualized Agricultural Non-Point Source Pollution Model (AnnAGNPS) Phosphorus Components

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AnnAGNPS – Annualized Agricultural Nonpoint Source Pollution Model

- Evaluates the effect of conservation practices for integrated watershed management planning (used in CEAP by ARS & NRCS).
- Uses RUSLE2 science and databases.
- Tracks pollutants from their source (fields, gully, channel, point source, feedlot).
- Linked to channel – lake/reservoir - groundwater models.
AnnAGNPS: the pollutant loading (PL) model

Erosion, yield, & loadings by type of PL:

• **Water**—rainfall, snowmelt, irrigation, & point sources.

• **Sediment by particle size-class and source:**
  ✷ clay;
  ✷ silt;
  ✷ sand;
  ✷ small aggregate; and
  ✷ large aggregate.

• **Chemicals (attached & dissolved):**
  ✷ nutrients—nitrogen, phosphorous, & organic carbon; and
  ✷ pesticides—any number, any kind.
Model Process Components

Loadings by source

- **Cells** (RUSLE Landscapes) — water, sediment, & chemicals.
- **Feedlots** — soluble nutrients.
- **Gullies** — sediment & chemicals.
- **Point Sources** — water & chemicals.
- **Reaches** — sediment yield & chemical transport.
- **Impoundments/Wetlands** — pollutant deposition
Watershed Water, Sediment, & Chemical Sources

Tracks loadings by source throughout the transport process
AnnAGNPS: Phosphorus Components

A simplification of phosphorus processes (Havlin et al., 1999)
AnnAGNPS: Phosphorus Components

Phosphorus processes simulated within AnnAGNPS

Mineral P
- Inorganic fertilizer
- Plant uptake
- Mineralization
- Stable
- Active

Organic P
- Humic substances
- Organic fertilizer
- Residue Decay
- Fresh
- Plant residue
- Residue mineralization
AnnAGNPS: Phosphorus Components

Phosphorus processes linked to the lake model CCHE-WQ

**CBOD**

Reaeration  Light, Temperature

**DO**

**PHYTO**

C: N: P

**NH₃**  **NO₃**  **PO₄**  **OP**

**ON**

Water Column

Sediment Layer

CBOD  DO  PHYTO  OP

Denitrification

**NO₃**  **NH₃**  **ON**  **PO₄**
**AnnAGNPS:** Phosphorus Components

- Top soil layer - 203.2 mm tillage surface soil layer
- Second soil layer - depth to an impervious layer or user supplied
- Simplification of the EPIC P model.
- Sediment-bound P is determined from the clay-sized fraction of soil erosion, which is also part of eroded aggregates.
- Adapts surface and subsurface residue decomposition routines from RUSLE2
- Users enter initial soil P levels or defaults of 1.5% OM for orgP and 0.75% for inorgP are used
- P saturation uncertainty impacting long term simulations
Assessment of Conservation Practice Effects on Phosphorus Loads from Grand Lake St. Marys Watershed, Ohio using AnnAGNPS

Objective

To determine where and if conservation practices can be placed and/or adopted to reduce phosphorus loadings to Grand Lake St Marys.
LANDUSE

Crops ~ 68%
Pasture ~ 7%
Forest ~ 6%
Developed ~ 16%
Other ~ 3%
Average Annual Monthly Phosphorus Loading Various Scenarios

![Phosphorus Loading Graph]

- **Existing Tillage**
- **No-Tillage**
- **Buffer w/ Existing Tillage**
- **Radish Cover**
- **NT-Buffer-Radish Cover**

**Y-axis:** Phosphorus Loading (lb/ac/yr)

**X-axis:** Jan, Feb, Mar, Apr, May, Jun, Jul, Aug, Sep, Oct, Nov, Dec
Phosphorus Loads to GLSM
Existing Conditions – 30 Year Simulation
Phosphorus Load Reduction From Conservation Practices

A. Conventional Tillage
B. Minimum Tillage
C. No-Tillage
D. Buffers w/ Conv. Till.
E. Rye Cover w/ Conv. Till.
F. Clover Cover w/ Conv. Till.
G. Wheat Cover w/ Conv. Till.
H. Vetch Cover w/ Conv. Till.
I. Radish Cover w/ Conv. Till.
J. No-Till w/ Radish Cover w/ Buffers
Contributed Phosphorus Load vs. Contributing Drainage Area

26% of the GLSM Watershed Contributes 50% of the Phosphorus Load
26% of the Area Contributes 50% of the Phosphorus Load to GLSM

Existing Conditions – 30 Year Simulation

5% of the GLSM watershed contributes 10% of the total P load (~3.5 km from the lake)
Phosphorus Loads to GLSM
Winter Wheat Cover – 30 Year Simulation

53% Phosphorus Load Reduction to GLSM with Winter Wheat Cover
Summary

- 26% of the watershed contributes 50% of the P loads to GLSM.
- 10% of the P loads entering GLSM originate near the lake boundary (within 3.5 km).
- Cover crops can reduce P loads by over 50% and up to 70%.
- Riparian buffers can reduce P loads to the lake by up to 37%.
General performance ratings for recommended statistics for a monthly time step.

<table>
<thead>
<tr>
<th>Performance Rating</th>
<th>RSR</th>
<th>NSE</th>
<th>Streamflow PBIAS (%)</th>
<th>Sediment PBIAS (%)</th>
<th>N, P PBIAS (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very good</td>
<td>0.00 &lt; RSR &lt; 0.50</td>
<td>0.75 &lt; NSE &lt; 1.00</td>
<td>PBIAS &lt; ±10</td>
<td>PBIAS &lt; ±15</td>
<td>PBIAS &lt; ±25</td>
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<tr>
<td>Good</td>
<td>0.50 &lt; RSR &lt; 0.60</td>
<td>0.65 &lt; NSE &lt; 0.75</td>
<td>±10 &lt; PBIAS &lt; ±15</td>
<td>±15 &lt; PBIAS &lt; ±30</td>
<td>±25 &lt; PBIAS &lt; ±40</td>
</tr>
<tr>
<td>Satisfactory</td>
<td>0.60 &lt; RSR &lt; 0.70</td>
<td>0.50 &lt; NSE &lt; 0.65</td>
<td>±15 &lt; PBIAS &lt; ±25</td>
<td>±30 &lt; PBIAS &lt; ±55</td>
<td>±40 &lt; PBIAS &lt; ±70</td>
</tr>
<tr>
<td>Unsatisfactory</td>
<td>RSR &gt; 0.70</td>
<td>NSE &lt; 0.50</td>
<td>PBIAS &gt; ±25</td>
<td>PBIAS &gt; ±55</td>
<td>PBIAS &gt; ±70</td>
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</tbody>
</table>


RMSE-observations standard deviation ratio (**RSR**) - incorporates the benefits of error index statistics and includes a scaling/normalization factor (Legates and McCabe, 1999).

Nash-Sutcliffe Efficiency (**NSE**) - indicates how well the plot of observed versus simulated data fits the 1:1 line (Nash and Sutcliffe, 1970).

Percent bias (**PBIAS**) - measures the average tendency of the simulated data to be larger or smaller than their observed counterparts (Gupta et al., 1999).
Thank you