Annual Phosphorus Loss Estimator (APLE) Model Sensitivity Analysis

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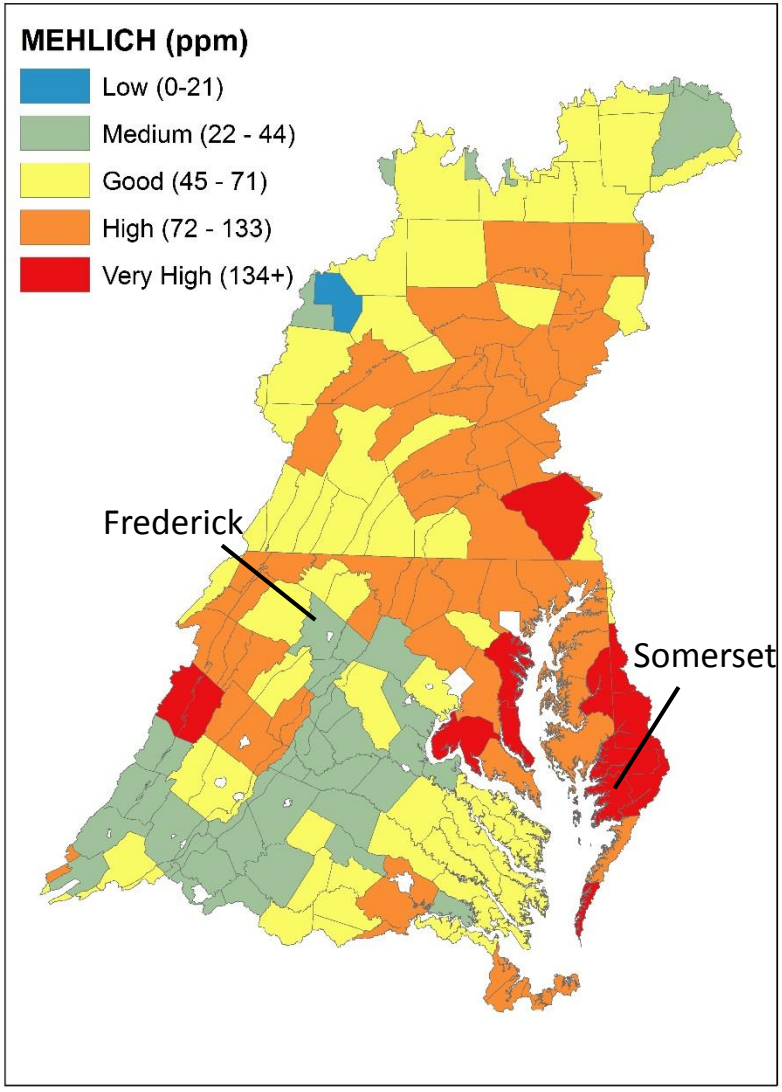
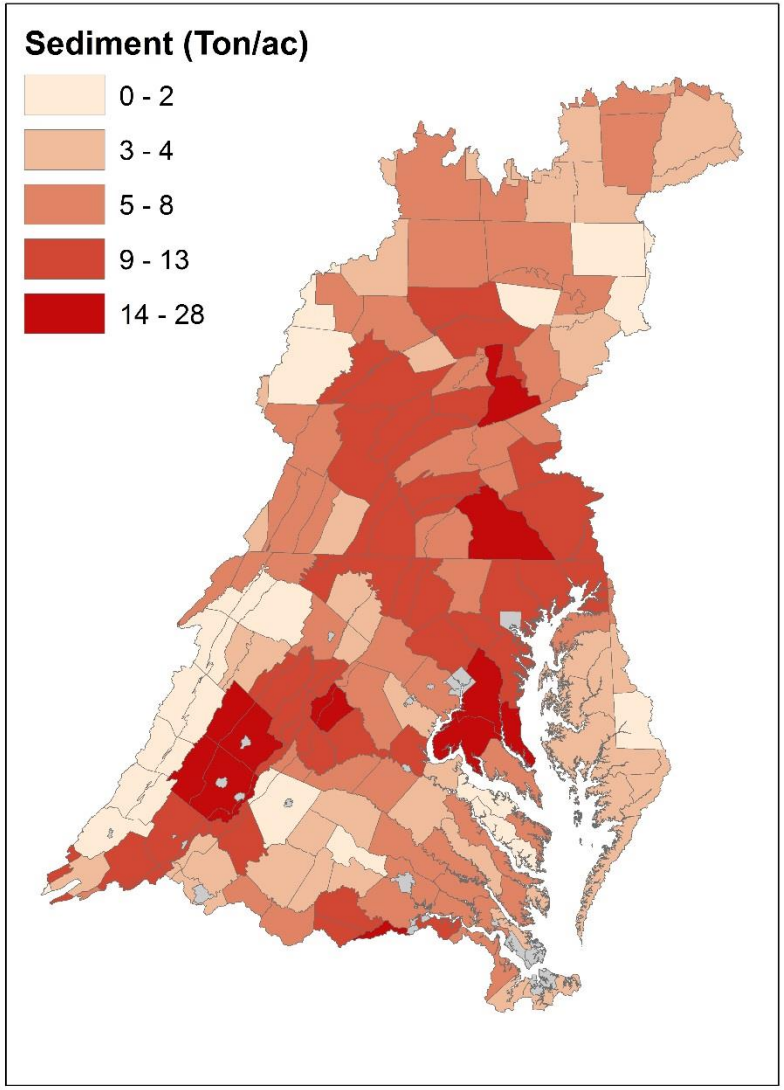
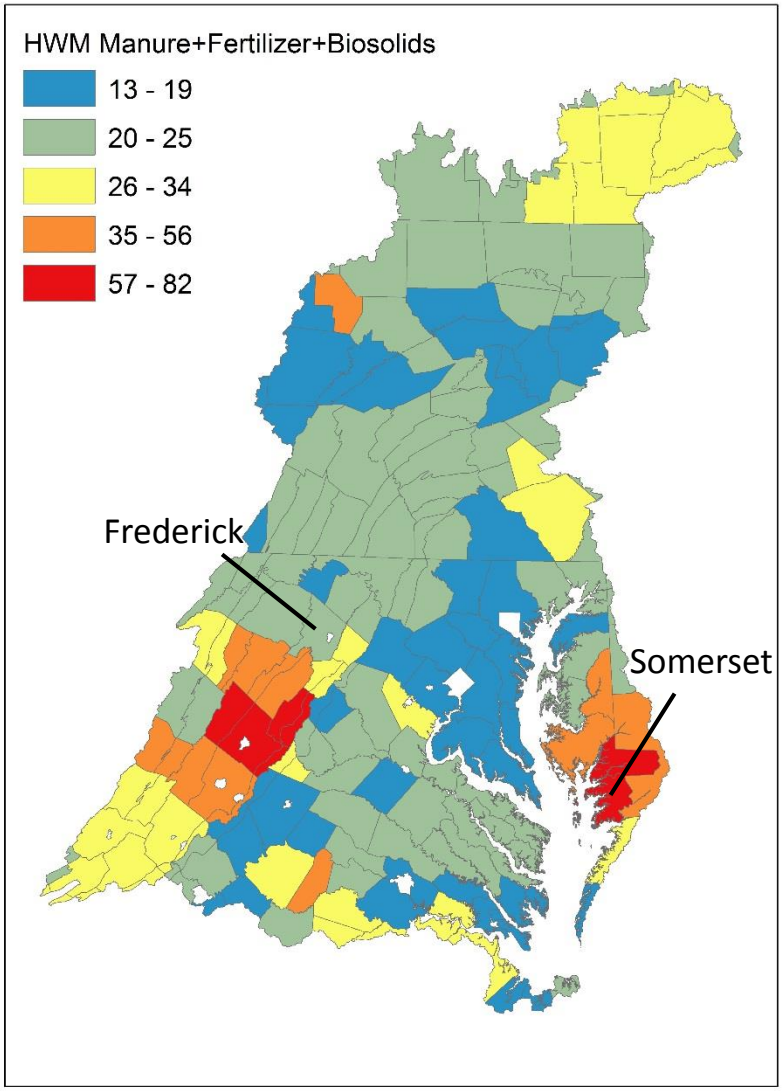
Objectives

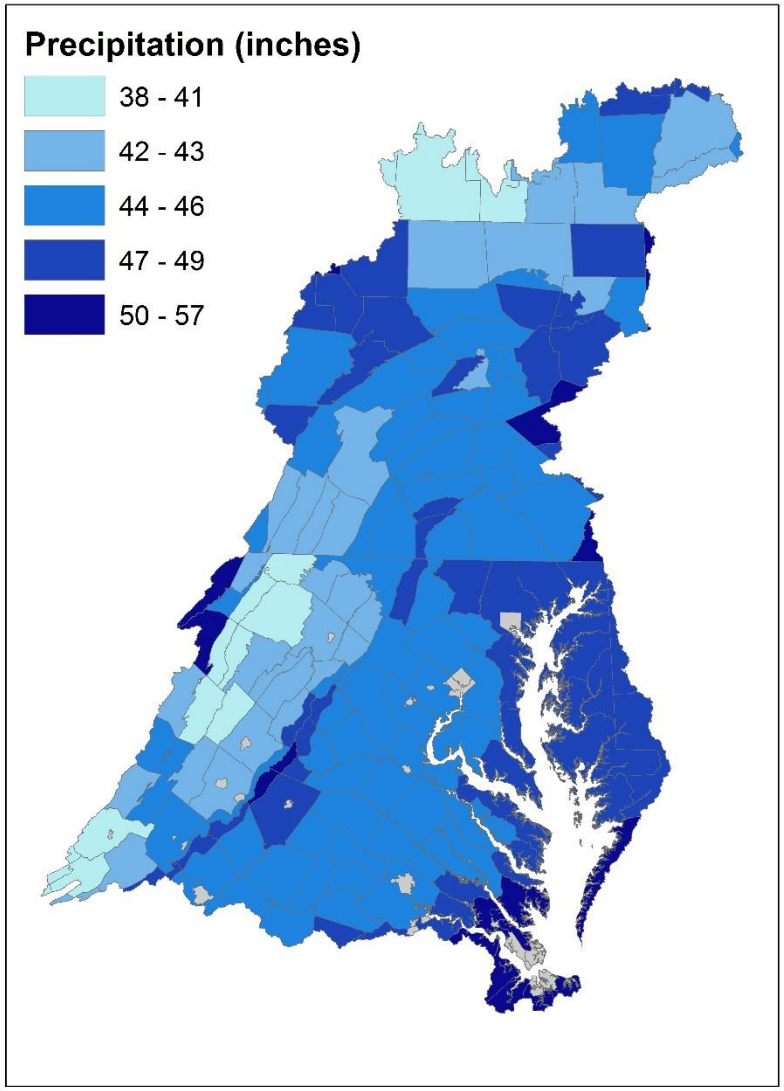
- To investigate different simulation periods to evaluate sensitivities
- To determine the effect of a change in fertilizer, manure, and uptake independent of soil P.
- To elaborate a plan to run ‘progress’ and ‘what if’ scenarios

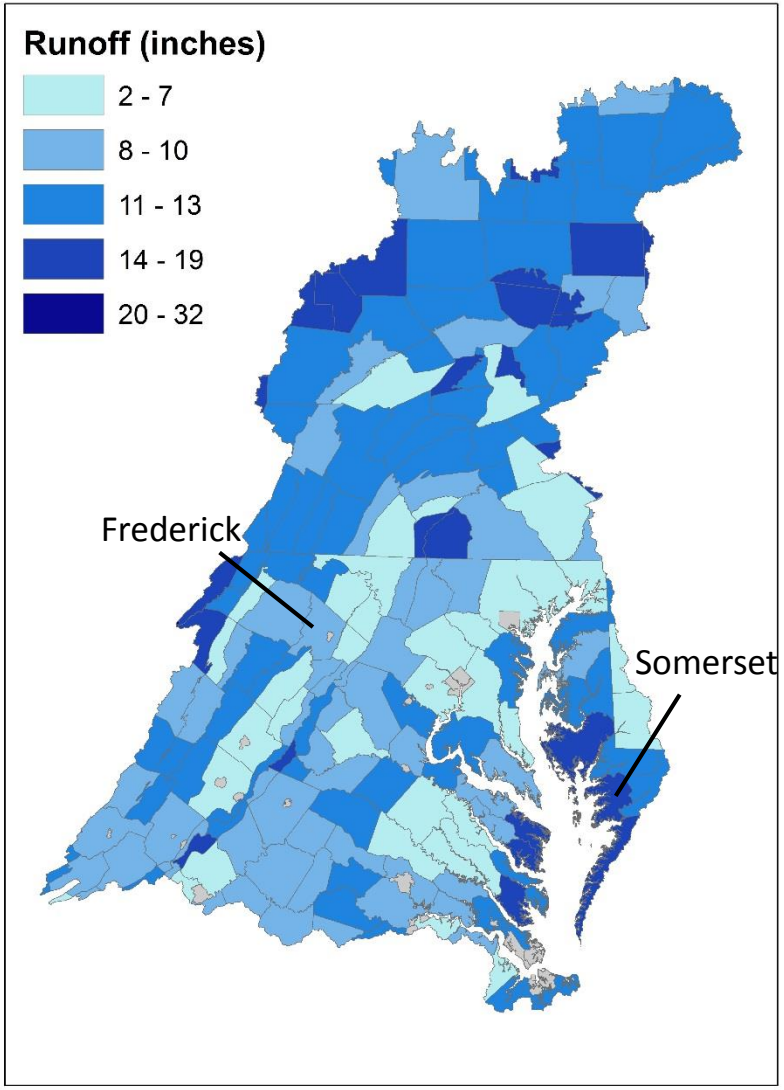


County	Manure Application (lbs/ac)	Fertlizer Application (lbs/ac)	Runoff/ Precipitation	Sediment (ton/ac)
Frederick, VA	**5**	**17**	**0.17**	**5.2**
Somerset, MD	**68**	**9**	**0.32**	**2.5**


Sediment (Ton/ac)
0 - 2
3 - 4
5 - 8
9 - 13
14 - 28


HWM Manure+Fertilizer+Biosolids
13 - 19
20 - 25
26 - 34
35 - 56
57 - 82
Frederick
Somerset


Precipitation (inches)
38 - 41
42 - 43
44 - 46
47 - 49
50 - 57


Runoff (inches)
2 - 7
8 - 10
11 - 13
14 - 19
20 - 32
Frederick
Somerset

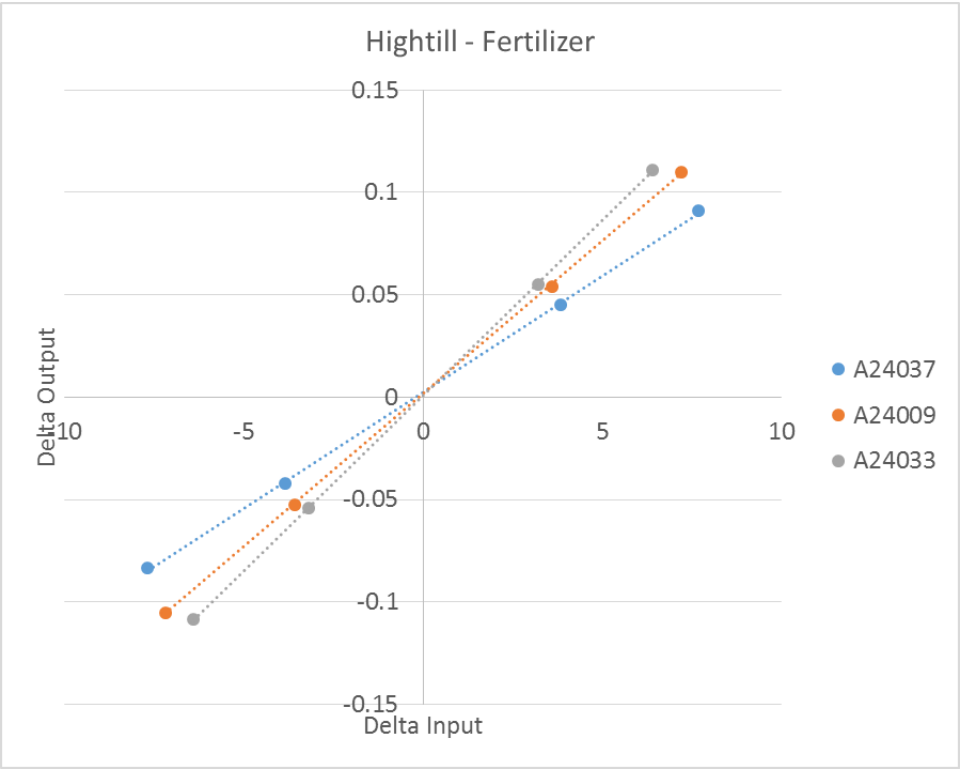
Sensitivity Scenarios

- Base scenario 1992-2005
- High till with manure and pasture (2 landuses)
- Fertilizer, Manure, Uptake, Runoff, Sediment, & Mehlich (6 variables)
- -60%, -30% , +30%, & +60% (4 scenarios)
- All P532 land segments (~300)

Relative Sensitivity (Sr)

$$S_r = \left(\frac{O - O_b}{I - I_b}\right)\frac{I_b}{O_b}$$

Where:
O = model output
I = model input
b = subscript represents the input and output value of the base scenario

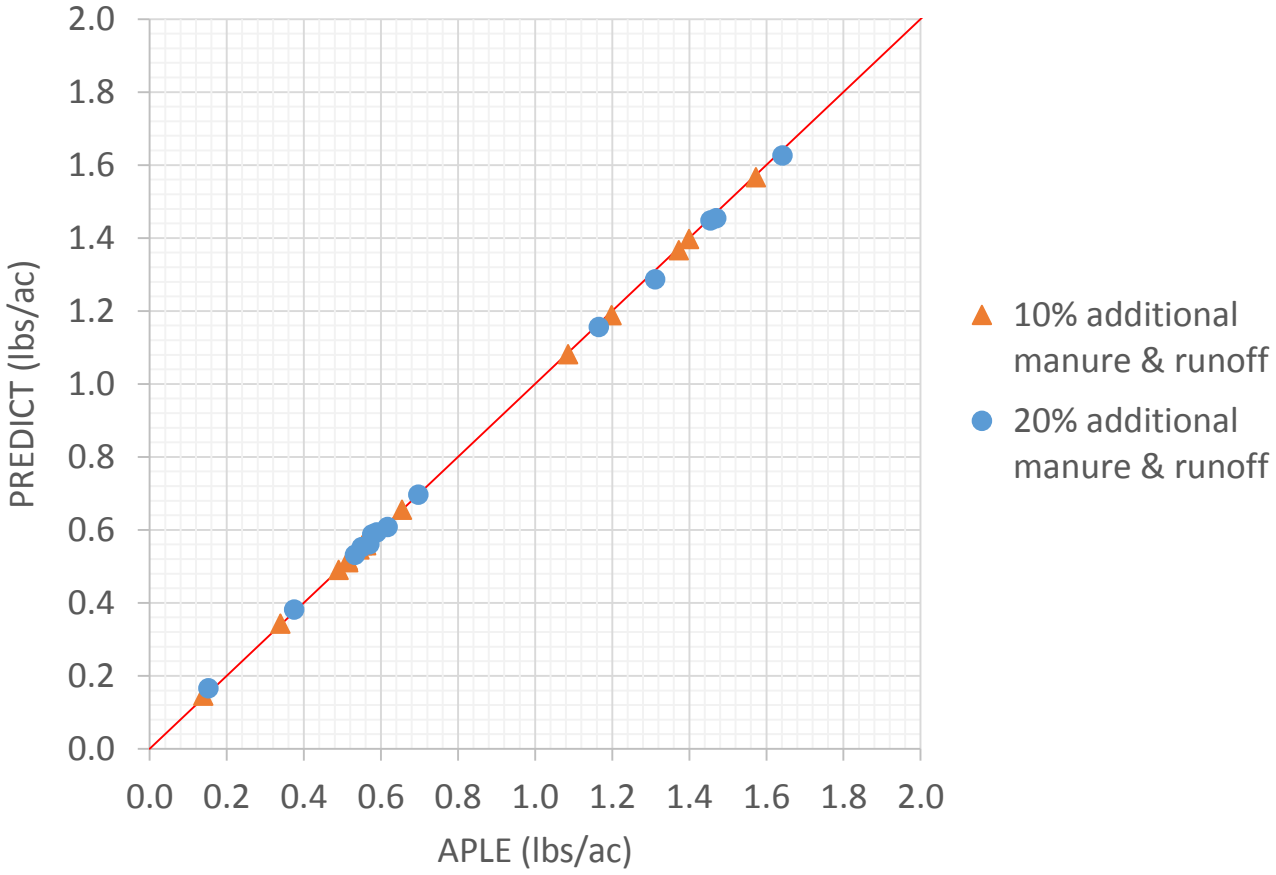


Relative Sensitivity	
Insensitive	$Sr < \|0.01\|$
Slightly sensitive	$\|0.01\| \leq Sr < \|0.10\|$
Moderately sensitive	$\|0.10\| \leq Sr < \|1.00\|$
Sensitive	$\|1.00\| \leq Sr < \|2.00\|$
Extremely sensitive	$Sr \geq \|2.00\|$

Storm,D. ,T. Dillaha, and S. Mostaghimi. 1986. Modeling phosphorus transport in surface runoff. *ASAE* 31(1):117-127.

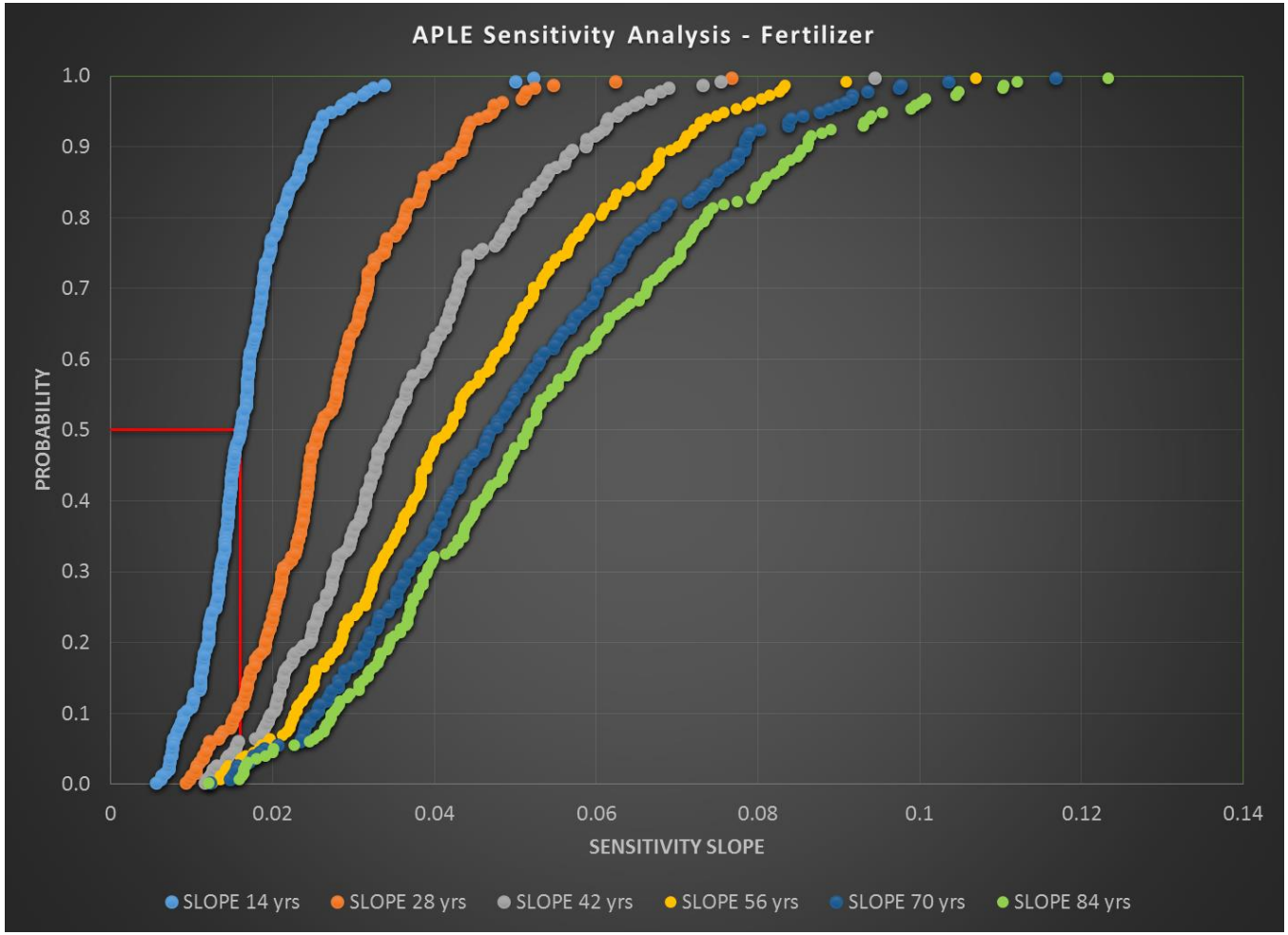
Validation

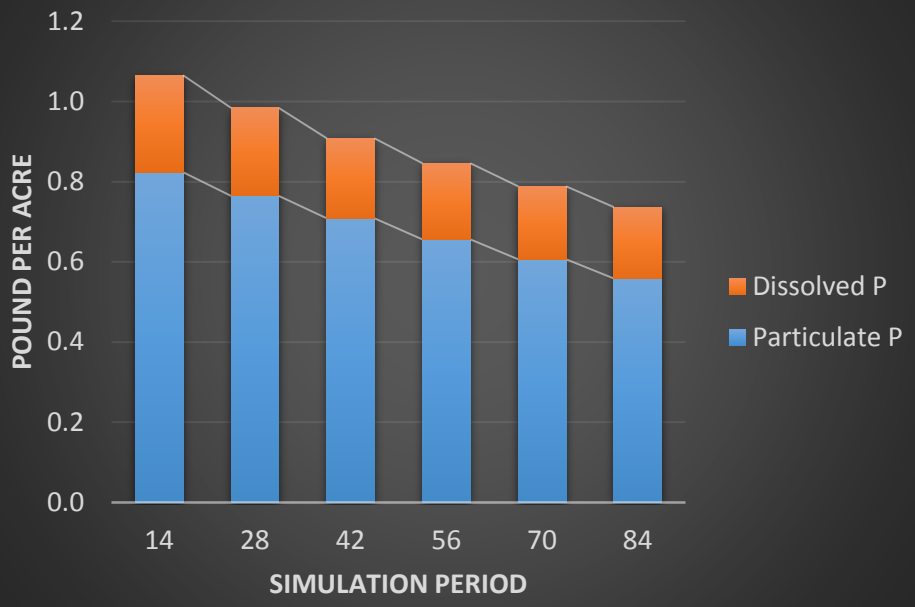
$$TPloss_{scenario} = TPloss_{base} + (\Delta\, Input_{\text{manure}} \times Sensitivity_{\text{manure}}) + (\Delta\, Input_{\text{runoff}} \times Sensitivity_{\text{runoff}})$$

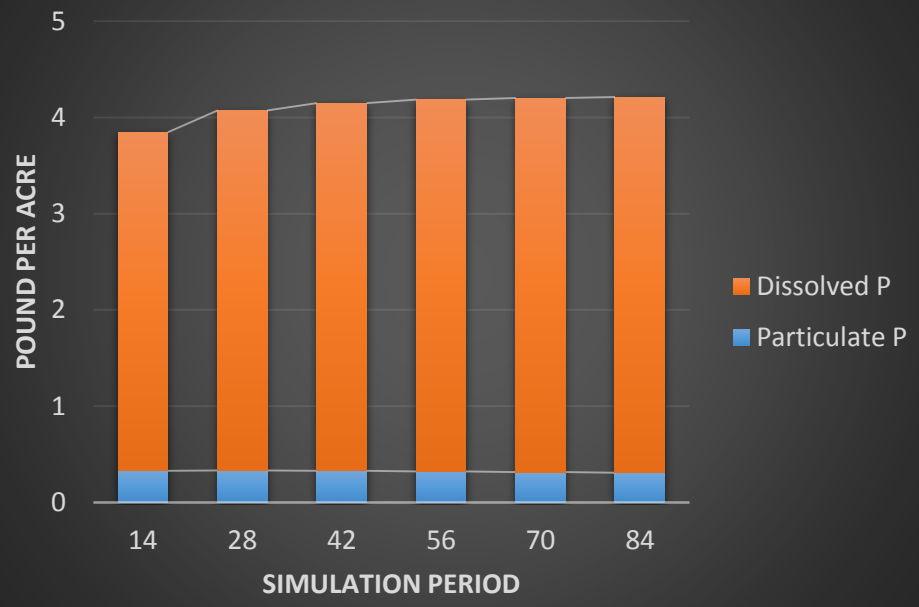


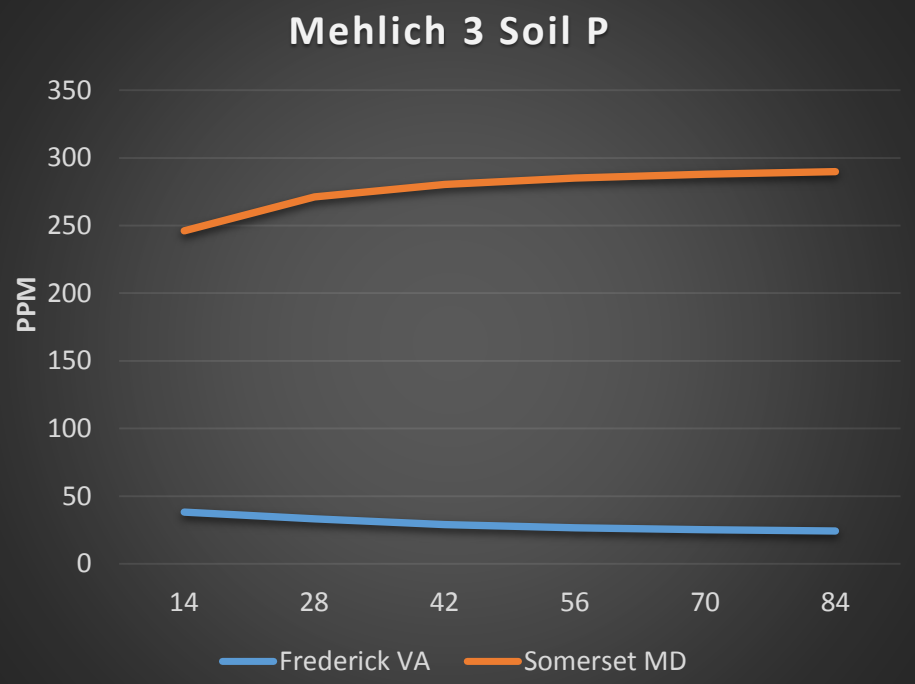
Different Simulation Periods to Evaluate Sensitivities

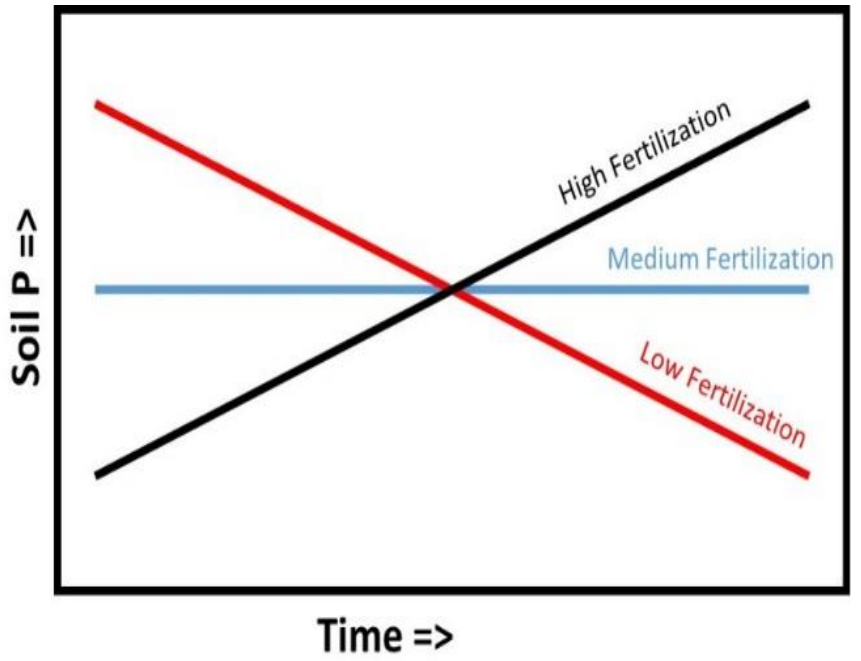
- We found that the median sensitivity slopes increased relative to the base case due to the change in Soil P.
- This suggests that, in order to determine the effect of change in inputs independent of soil P, mehlich inputs would need to be held constant during the simulation.



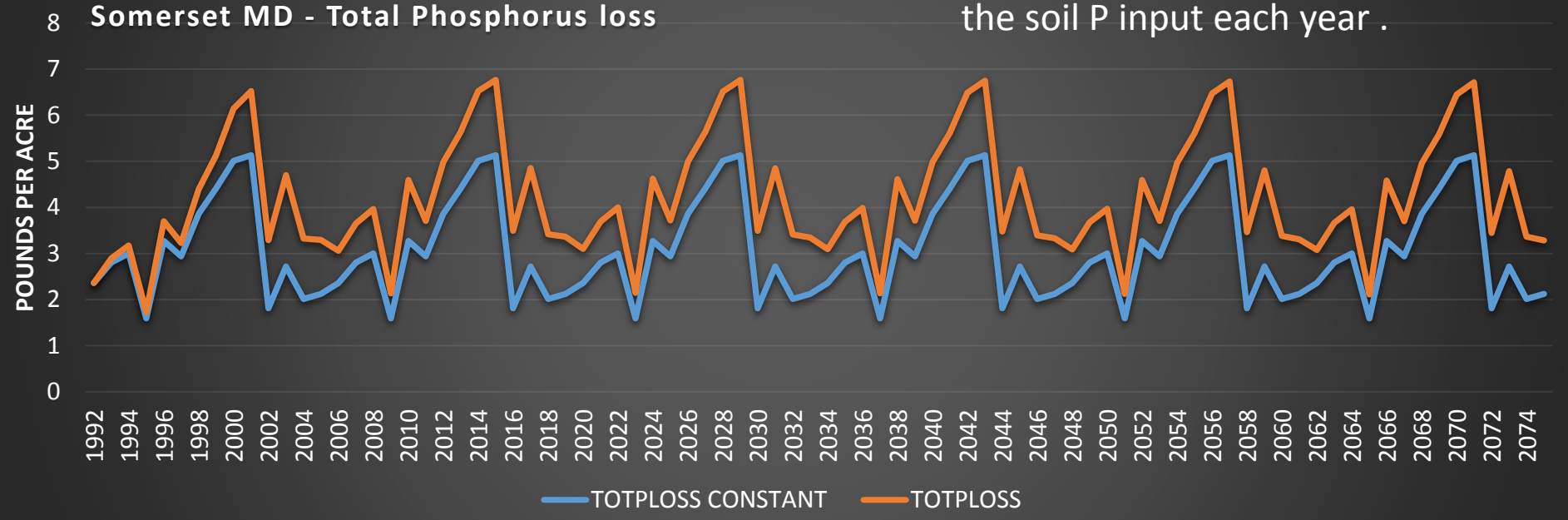

Frederick VA – Phosphorus Loss
1.2
1.0
0.8
0.6
0.4
0.2
0.0
POUND PER ACRE
14
28
42
56
70
84
SIMULATION PERIOD
Dissolved P
Particulate P

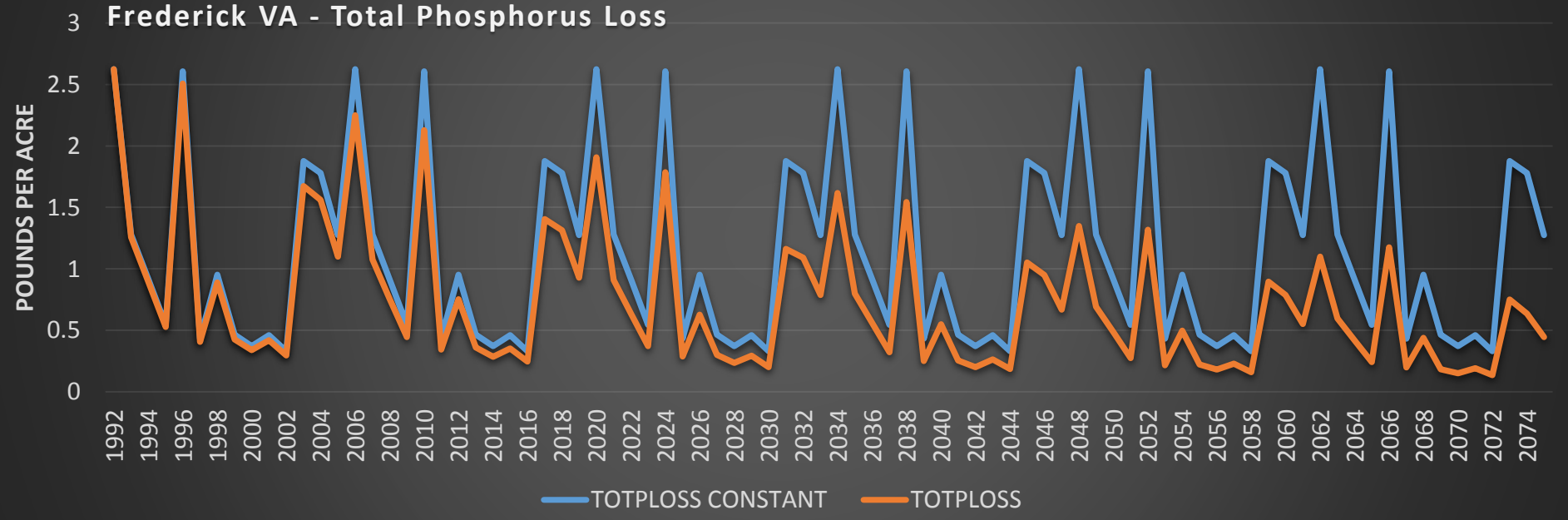

Somerset MD – Phosphorus Loss
5
4
3
2
1
0
POUND PER ACRE
14
28
42
56
70
84
SIMULATION PERIOD
Dissolved P
Particulate P


Mehlich 3 Soil P
350
300
250
200
150
100
50
0
PPM
14
28
42
56
70
84
Frederick VA
Somerset MD


Soil P =>
High Fertilization
Medium Fertilization
Low Fertilization
Time =>

The APLE code was modified to reset the soil P input each year .





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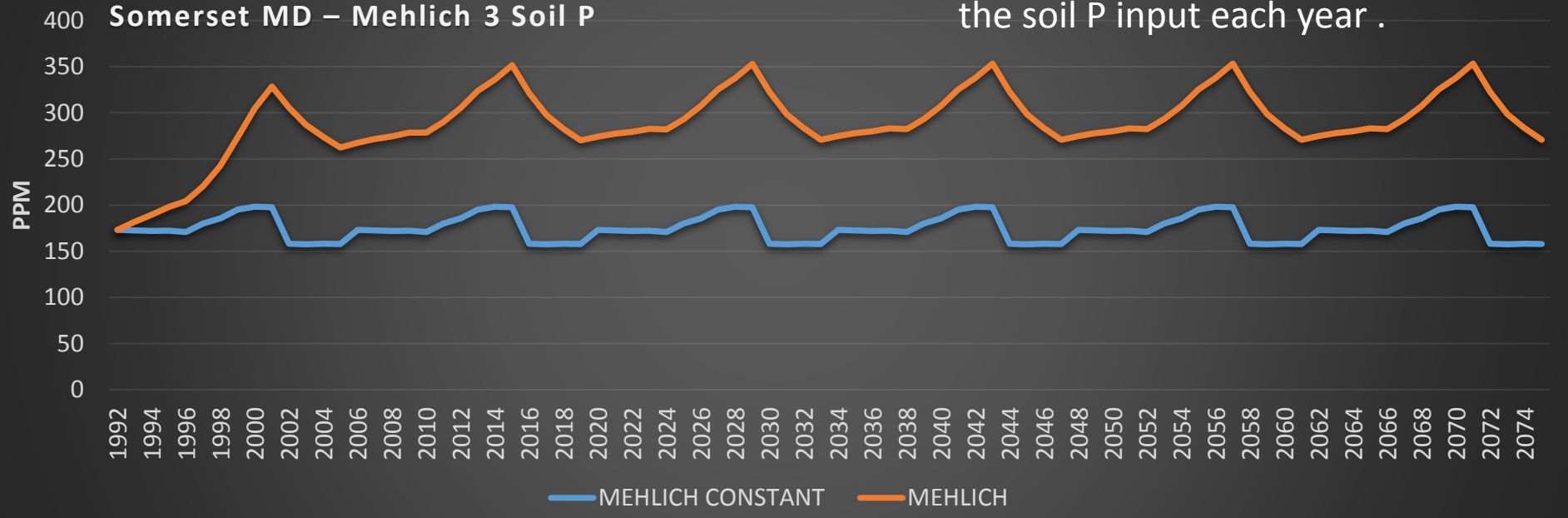
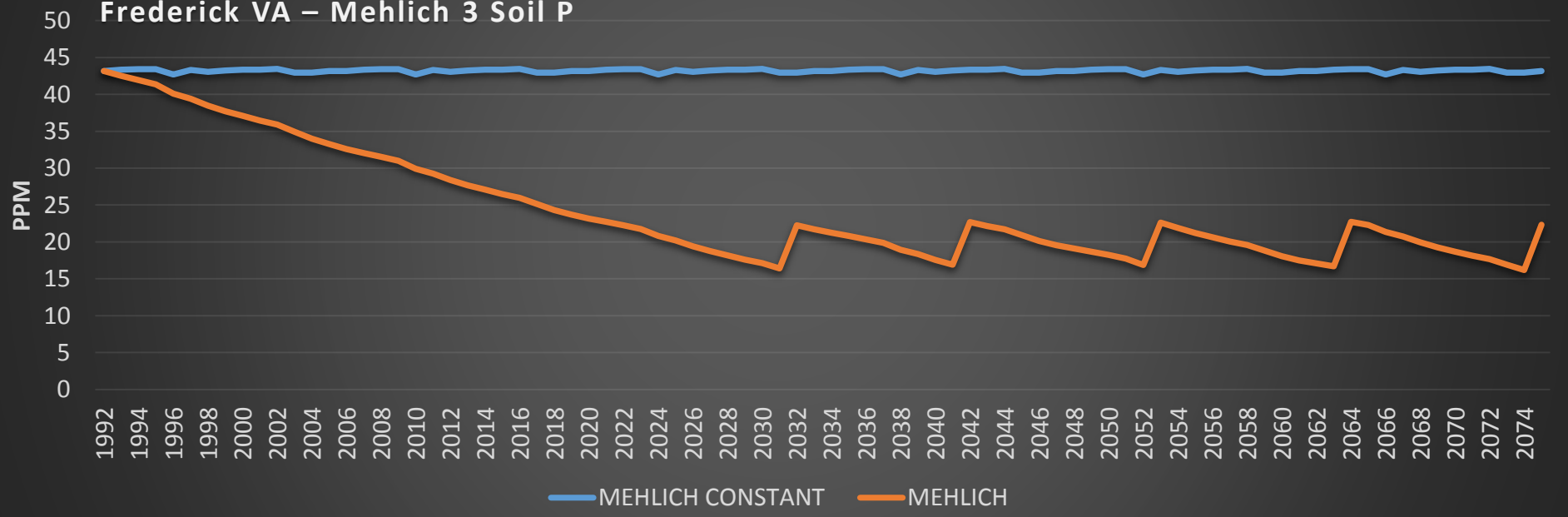




APLE Hightill Landuse Sensitivities using Constant Mehlich 3 Soil P

Table 1. Phosphorus Loss APLE Model Sensitivity to change in inputs

Inputs	Units	MEDIAN SLOPE	MEDIAN SR	Relative Sensitivity
Mehlich	ppm	0.015	0.696	Moderately sensitive
Sediment	ton/ac	0.168	0.633	Moderately sensitive
Runoff	inches	0.057	0.403	Moderately sensitive
Manure	lbs/acre	0.007	0.111	Moderately sensitive
Fertilizer	lbs/acre	0.004	0.068	Slightly sensitive
Uptake	lbs/acre	0	0	Insensitive

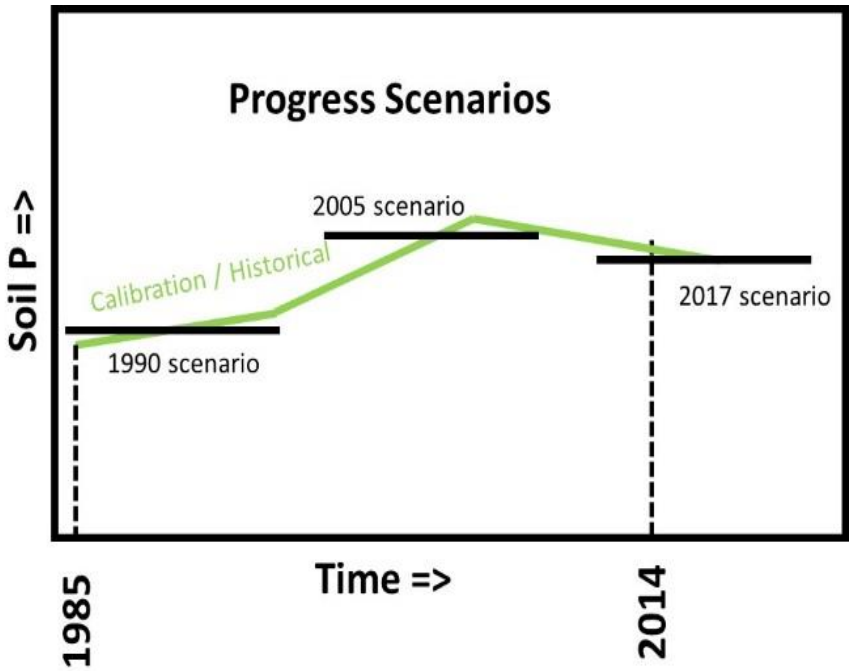
Table 2. Mehlich 3 Soil P APLE Model Sensitivity to change in inputs

Inputs	Units	MEDIAN SLOPE	MEDIAN SR	Relative Sensitivity
Uptake	ppm	-0.185	0.070	Slightly sensitive
Fertilizer	lbs/acre	0.190	0.063	Slightly sensitive
Manure	lbs/acre	0.184	0.060	Slightly sensitive
Sediment	ton/ac	-0.061	0.005	Insensitive
Runoff	inches	-0.019	0.003	Insensitive

Progress Scenarios

- A time series of Mehlich 3 Soil P for each land use and land segment needs to be generated using APLE, calibrated to observed data where available.

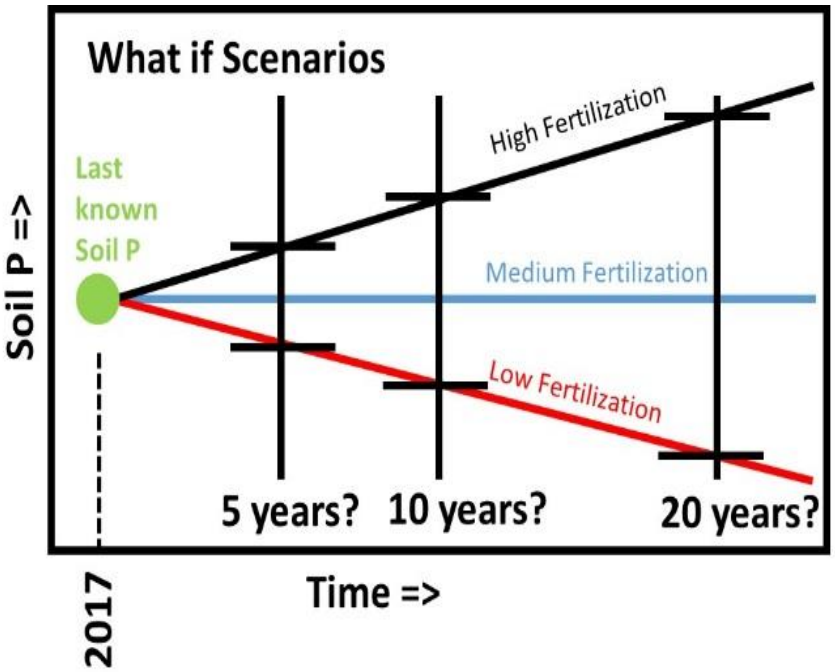
- We would use the difference between the soil P in the year of the progress run and the average soil P over the calibration time period together with the sensitivities in Table 1.



$$TPloss_{scenario} = TPloss_{Calib} + (\Delta\, mehlich\ Input_1 \times mehlich\ Sensitivity_1) + \cdots + (\Delta\, Input_n \times Sensitivity_n)$$

‘What if’ Scenarios

- For future scenarios, the change in soil P would be dependent on the length of time.
- We would determine the soil P at some point in the future using the change in inputs, the sensitivities in Table 2 and the length of time.
- This is not a technical issue, but an issue for the managers to decide



$$Mehlich_{scenario} = Mehlich_{Calib} + (\Delta \text{ fertilizer } Input_1 \times fertilizer\ Sensitivity_1 \times \Delta\text{years}) + \cdots + (\Delta\ Input_n \times Sensitivity_n \times \Delta\text{years})$$