Surface Water Assessments in the U.S. (and the World)

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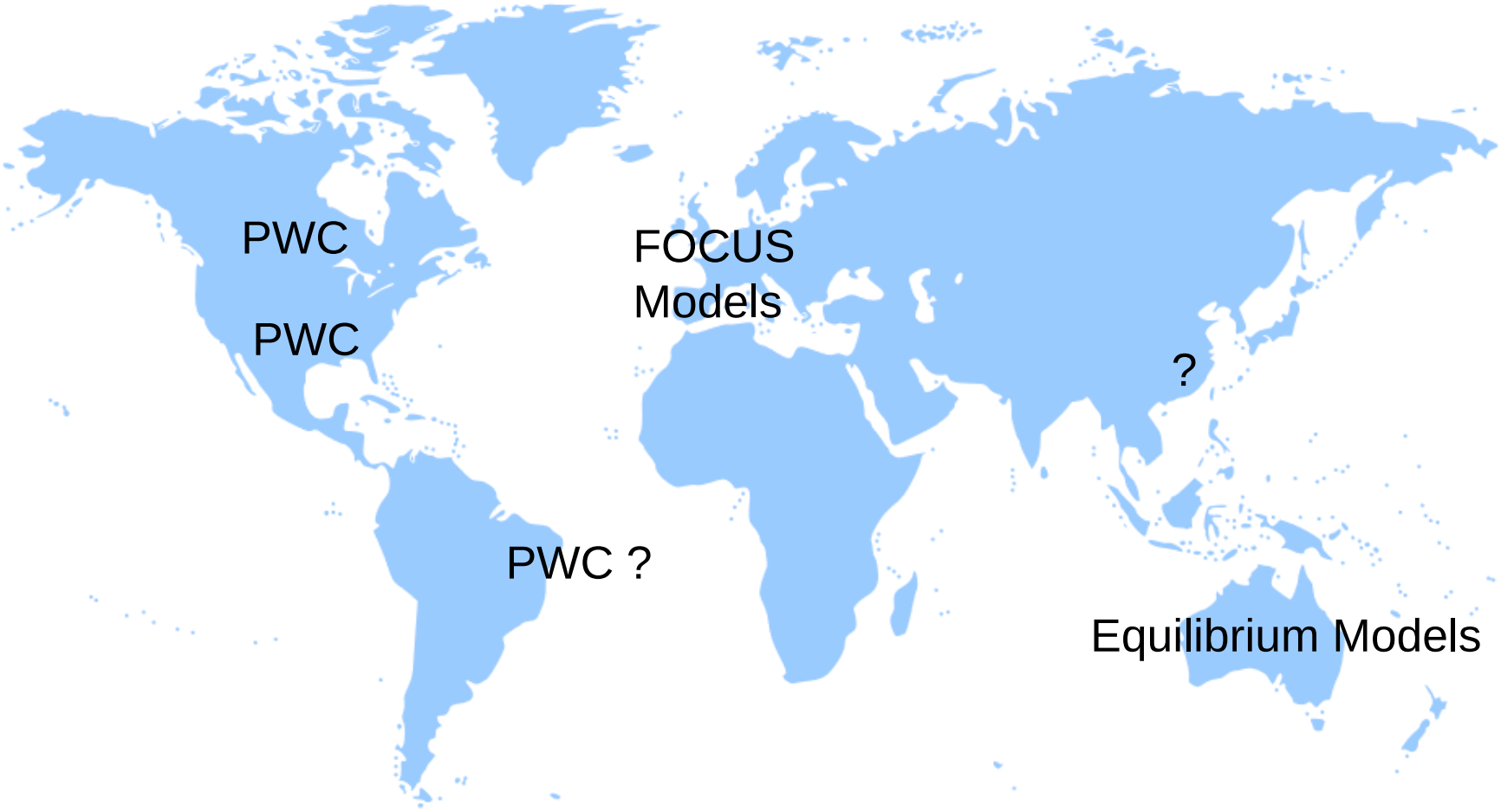
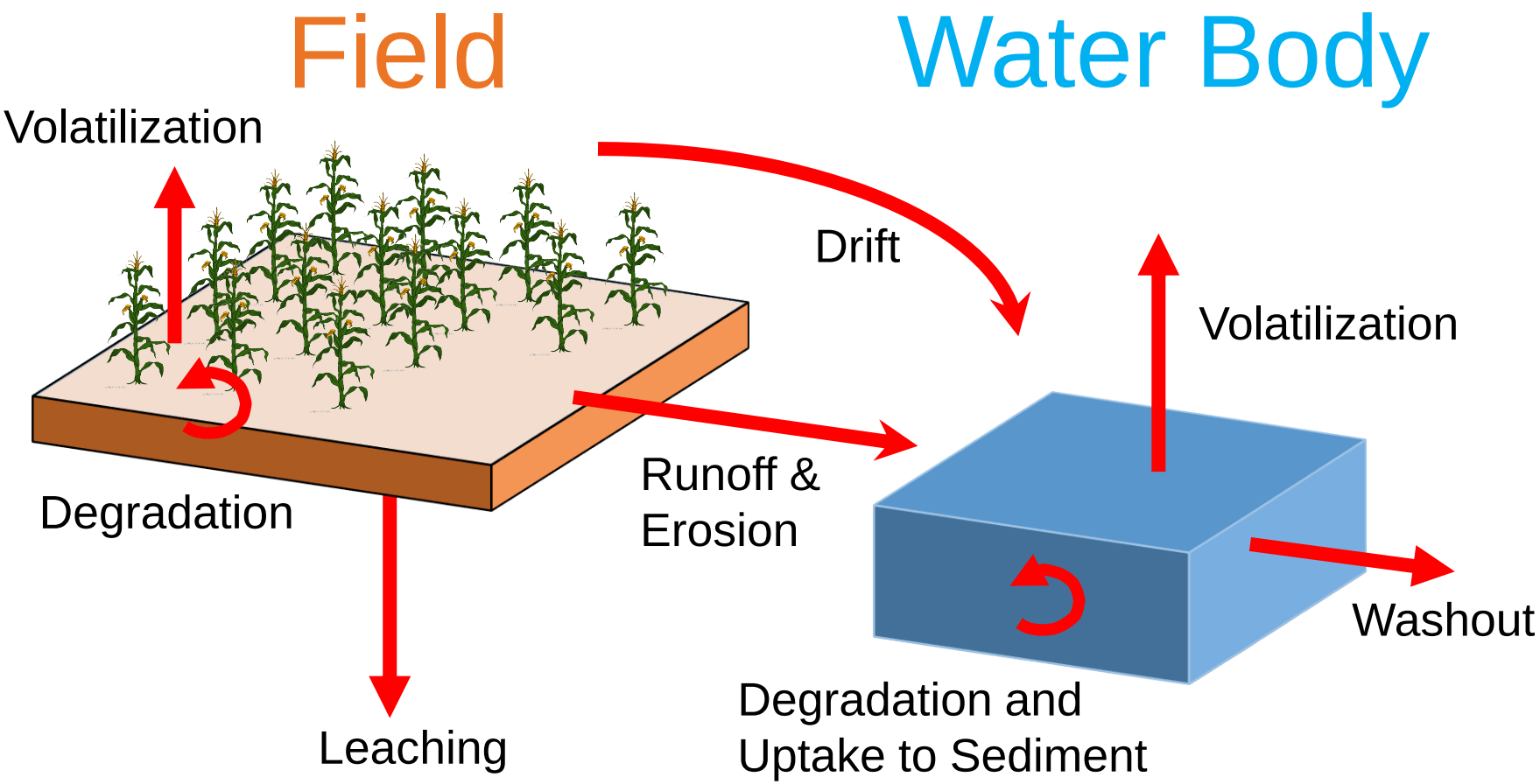
World Map of Surface Water Model Use



Part 1:
Surface Water Modeling Concepts

Concept of Pesticide Transport to Surface Water:

Generally the same for North America and EU



Rough Comparison of USEPA & EU (FOCUS) Surface Water

Similar concepts: field & water body

Similar implementation: PRZM5 & VVWM vs. PRZM & TOXSWA

Similar representation: regional output (not site specific)

FOCUS is a bit more mechanistic while EPA more generalist:

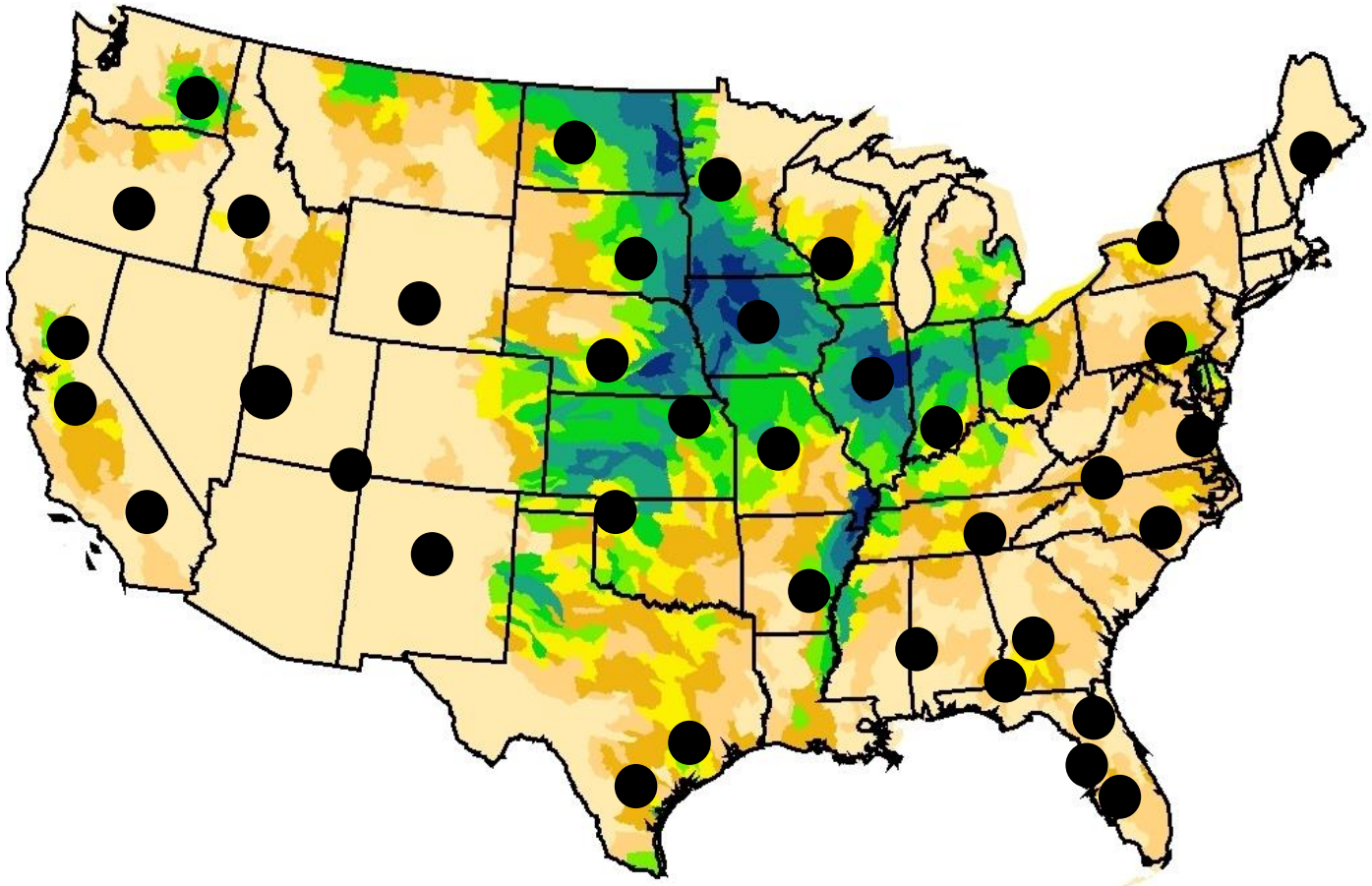
nonequilibrium, nonlinearity, macropores & drainage, parent-daughter degradation

vs.

linear equilibrium, comprehensive runoff, total toxic degradation

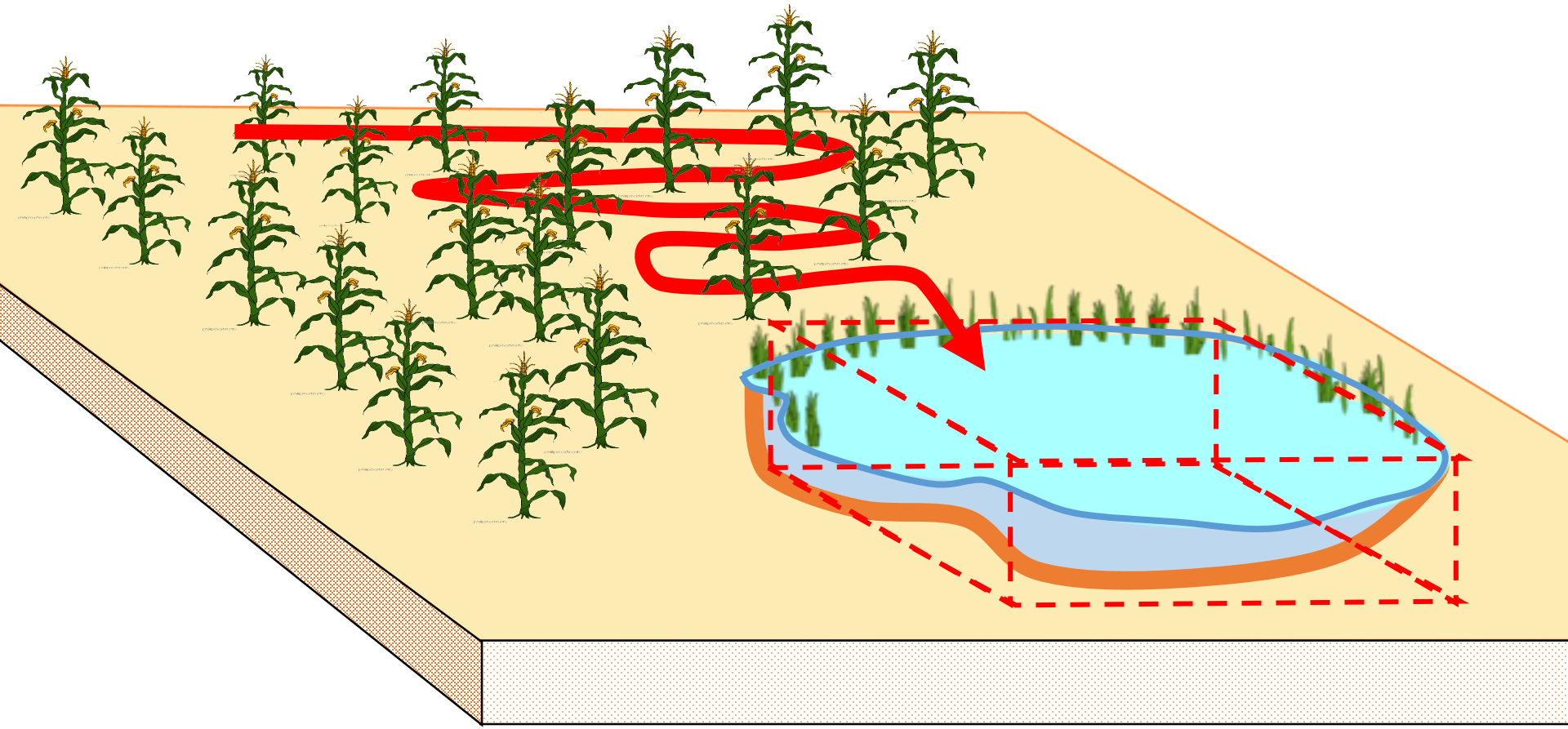
Part 2:
The USEPA Process for Surface Water Modeling

Standard Scenario Locations*

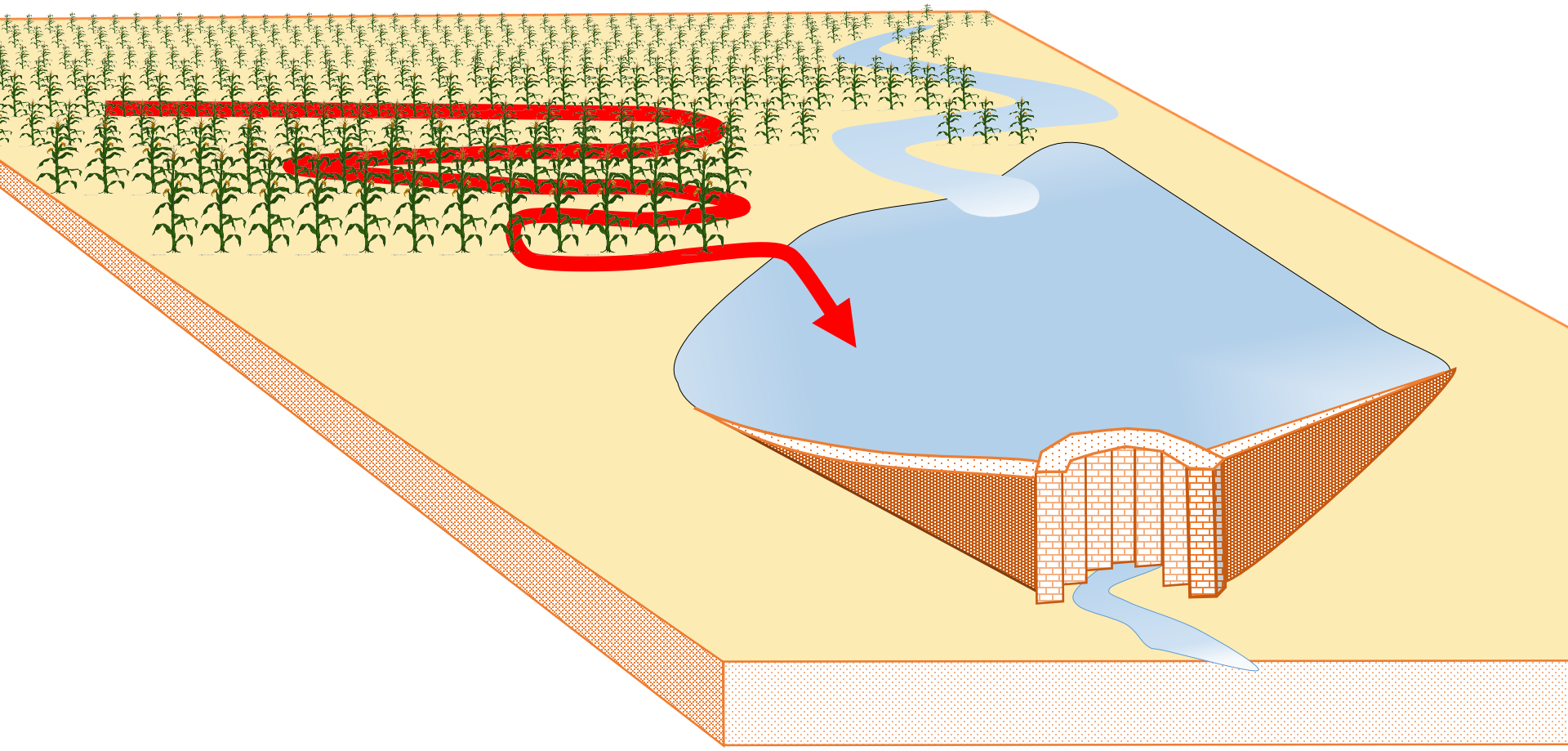


*for illustrative purposes, not accurate

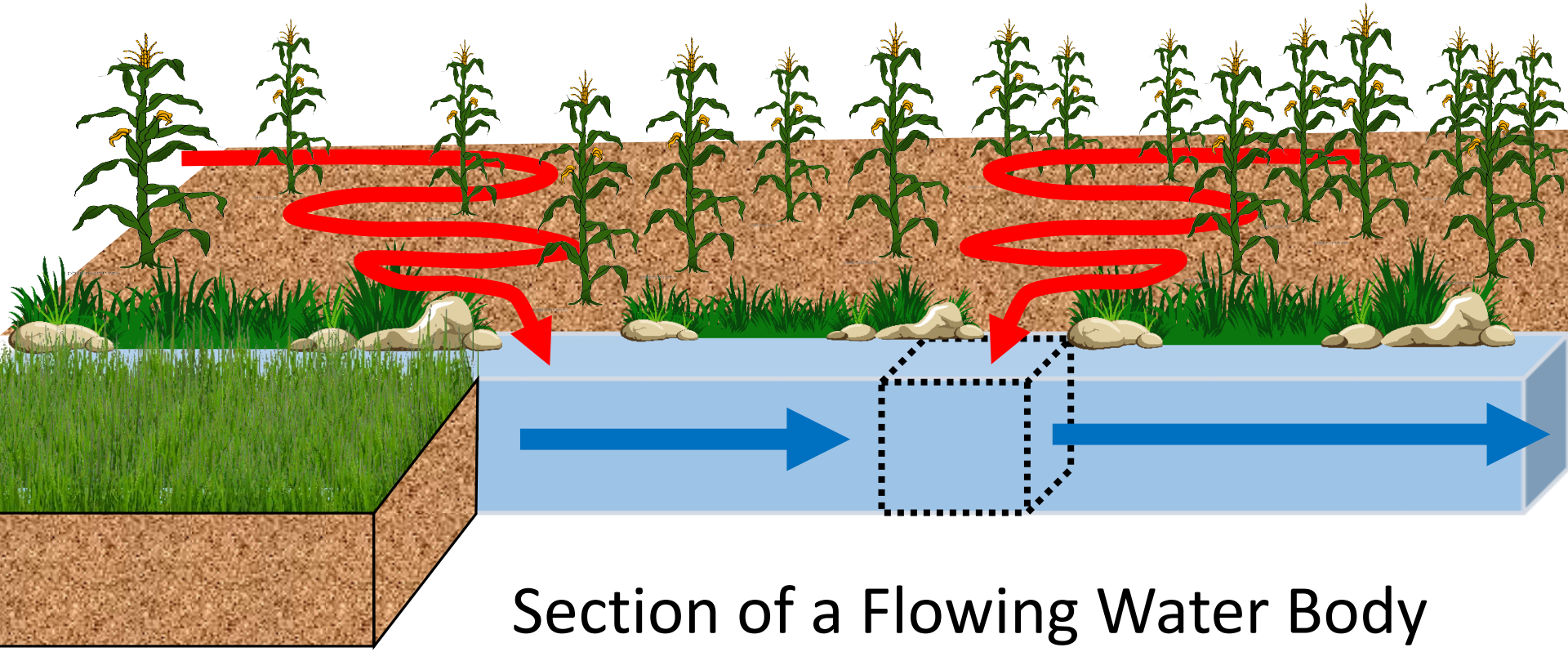
Confined Pond



Flow-Through Reservoir



Flowing Water

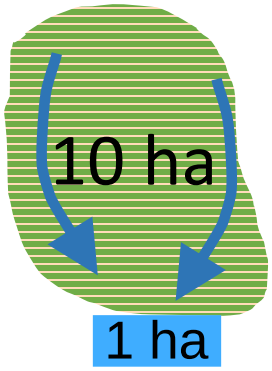


Section of a Flowing Water Body

The US Standard Fields & Waterbodies

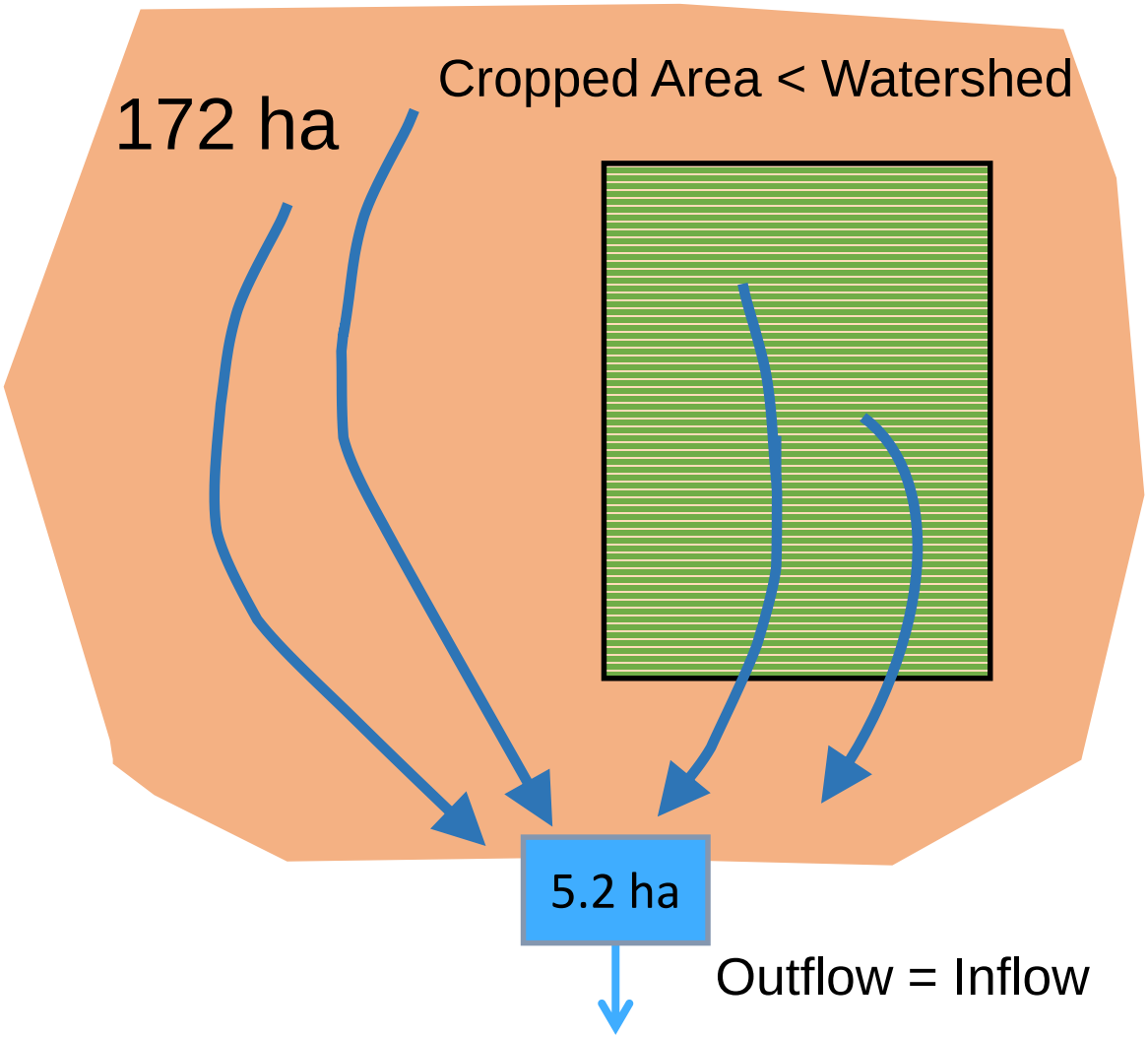
Ecological

100% Cropped Area



No Outflow

Human Health



Traditional Tiering Process

Implementation was time consuming and required specialized knowledge

Thus, The Traditional Tiering Process was Created:

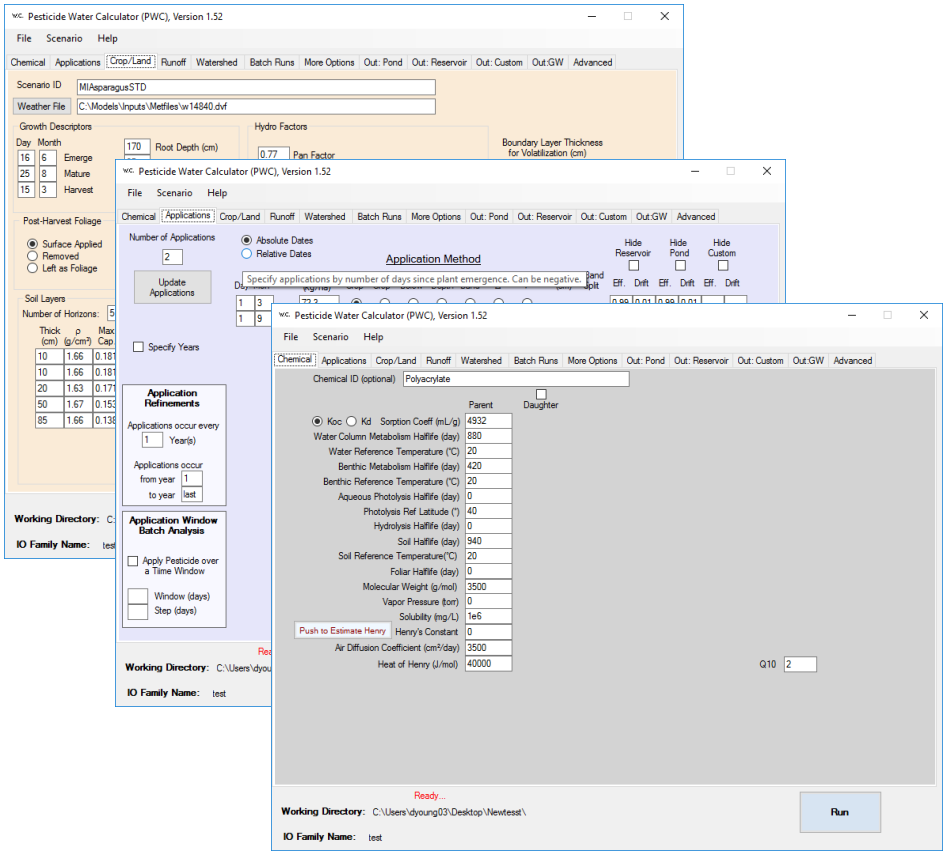
1st Simple Conservative: e.g., GENEEC, FIRST, other equilibrium models

2nd More Complex: Detailed landscape and mechanistic chemical processes e.g., PRZM-EXAMS

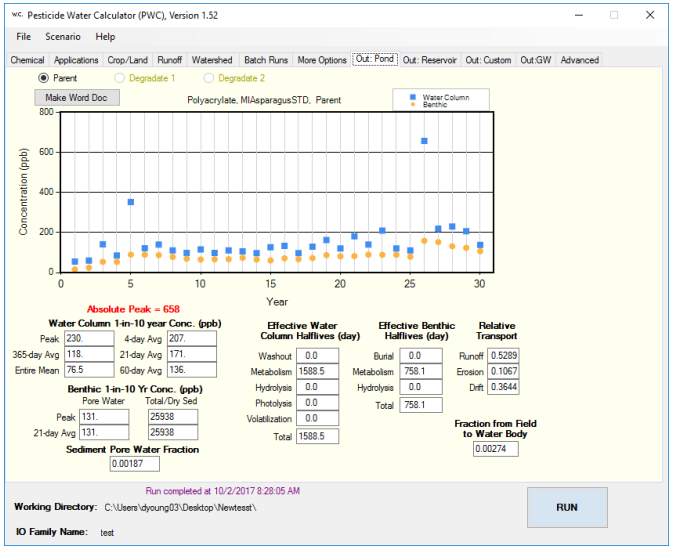
Now with new software improvements, Tier 2 is easier to perform…

…introducing the Pesticide Water Calculator (PWC)

input

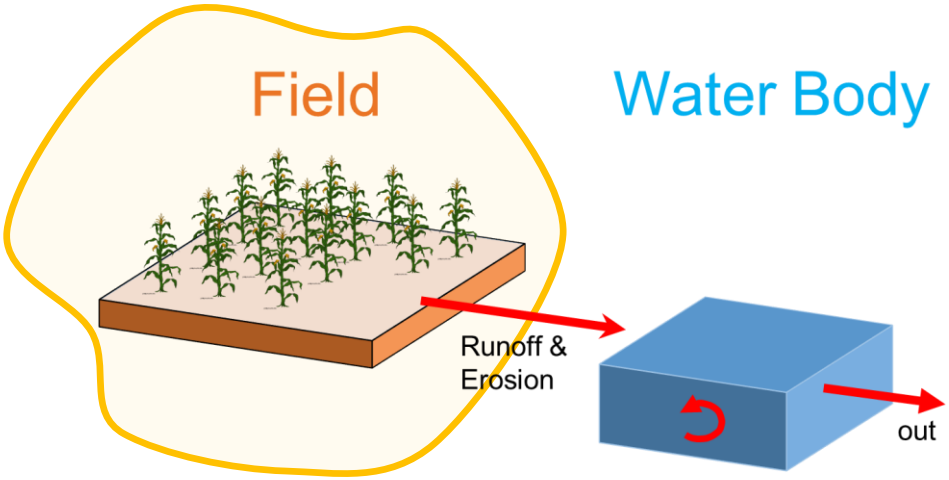


output

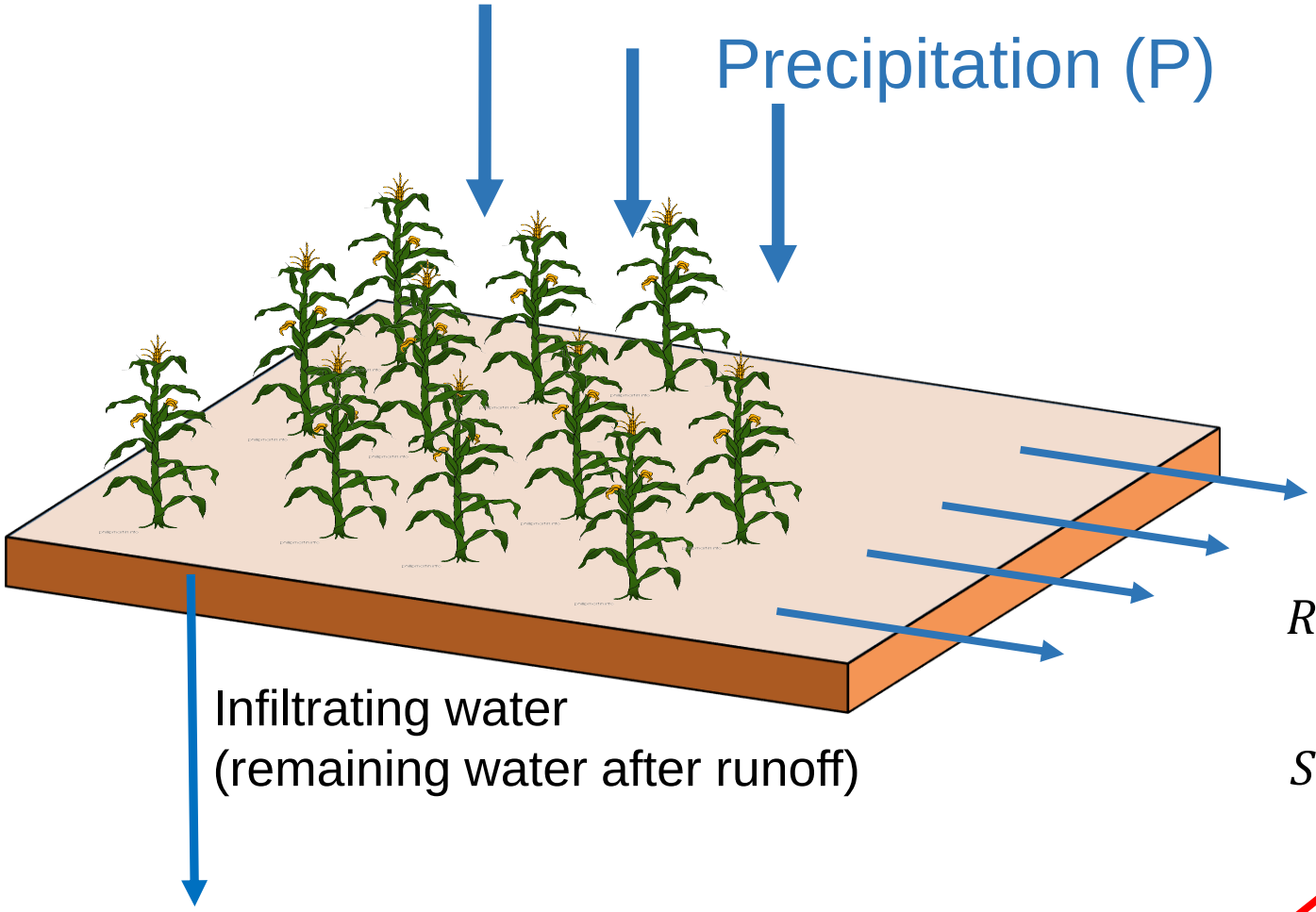


Because of the ease of the Tier 2 procedure, traditional Tier 1 assessments are not being used.

Part 3. Behind the Model: Field Hydrology & Chemical Transport



Field Runoff



$$R = \frac{(P - S)^2}{(P - 0.8S)}$$

$$S = \frac{100}{CN} - 10$$

Curve Number (CN):
tabulated values based on
Soil Classification & Crop

Curve Numbers:
National Engineering Handbook, Chapter 9, NRCS/USDA

Table 9–1 Runoff curve numbers for agricultural lands [1/]

Cover description			CN for hydrologic soil group			
covertype	treatment [2/]	hydrologic condition [3/]	A	B	C	D
Fallow	Bare Soil	---	77	86	91	94
	Crop residue cover (CR)	Poor	76	85	90	93
		Good	74	83	88	90
Row crops	Straight row (SR)	Poor	72	81	88	91
		Good	67	78	85	89
	SR + CR	Poor	71	80	87	90
		Good	64	75	82	85
	Contoured (C)	Poor	70	79	84	88
		Good	65	75	82	86
	C + CR	Poor	69	78	83	87
		Good	64	74	81	85
	Contoured & terraced (C & T)	Poor	66	74	80	82
		Good	62	71	78	81
	C & T + CR	Poor	65	73	79	81
		Good	61	70	77	80
Small grain	SR	Poor	65	76	84	88
		Good	63	75	83	87
	SR + CR	Poor	64	75	83	86
		Good	60	72	80	84
	C	Poor	63	74	82	85
		Good	61	73	81	84
	C + CR	Poor	62	73	81	84
		Good	60	72	80	83
	C & T	Poor	61	72	79	82
		Good	59	70	78	81
	C & T + CR	Poor	60	71	78	81
		Good	58	69	77	80
Close-seeded or broadcast legumes or rotation meadow	SR	Poor	66	77	85	89
		Good	58	72	81	85
	C	Poor	64	75	83	85
		Good	55	69	78	83
	C & T	Poor	63	73	80	83
		Good	51	67	76	80

…Continued Table 9-1

Pasture, grassland, or range-continuous forage for grazing [4/]	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Meadow-continuous grass, protected from grazing and generally mowed for hay	Good	30	58	71	78
Brush-brush-forbs-grass mixture with brush the major element [5/]	Poor	48	67	77	83
	Fair	35	56	70	77
	Good	30 [6/]	48	65	73
Woods-grass combination (orchard or tree farm) [7/]	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79
Woods [8/]	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	30	55	70	77
Farmstead–buildings, lanes, driveways, and surrounding lots	---	59	74	82	86
Roads (including right-of-way):					
Dirt	---	72	82	87	89
Gravel	---	76	85	89	91

1/ Average runoff condition, and I_a=0.2s.

2/ Crop residue cover applies only if residue is on at least 5 percent of the surface throughout the year.

3/ Hydrologic condition is based on combinations of factors that affect infiltration and runoff, including (a) density and canopy of vegetative areas, (b) amount of year-round cover, (c) amount of grass or close-seeded legumes, (d) percent of residue cover on the land surface (good ≥20%), and (e) degree of surface toughness.
Poor: Factors impair infiltration and tend to increase runoff.
Good: Factors encourage average and better then average infiltration and tend to decrease runoff.
For conservation tillage poor hydrologic condition, 5 to 20 percent of the surface is covered with residue (less than 750 pounds per acre for row crops or 300 pounds per acre for small grain).
For conservation tillage good hydrologic condition, more than 20 percent of the surface is covered with residue (greater than 750 pounds per acre for row crops or 300 pounds per acre for small grain).

4/ Poor: < 50% ground cover or heavily grazed with no mulch.
Fair: 50 to 75% ground cover and not heavily grazed.
Good: > 75% ground cover and lightly or only occasionally grazed.

5/ Poor: < 50% ground cover.
Fair: 50 to 75% ground cover.
Good: > 75% ground cover.

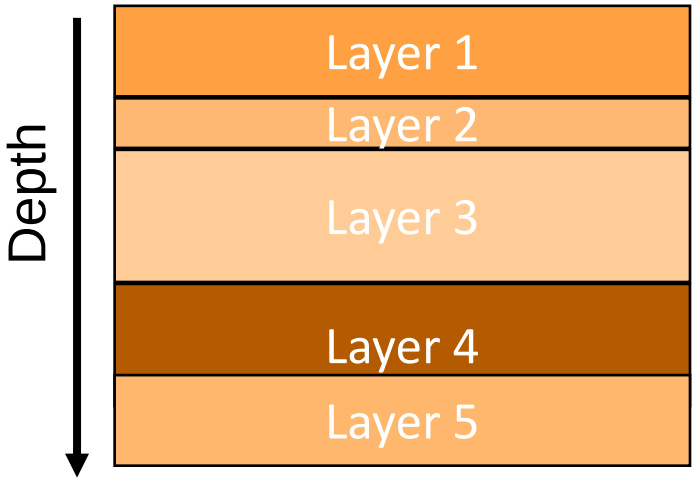
6/ If actual curve number is less than 30, use CN = 30 for runoff computation.

7/ CNs shown were computed for areas with 50 percent woods and 50 percent grass (pasture) cover. Other combinations of conditions may be computed from the CNs for woods and pasture.

8/ Poor: Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.
Fair: Woods are grazed, but not burned, and some forest litter covers the soil.
Good: Woods are protected from grazing, and litter and brush adequately cover the soil.

Soil Profile Description

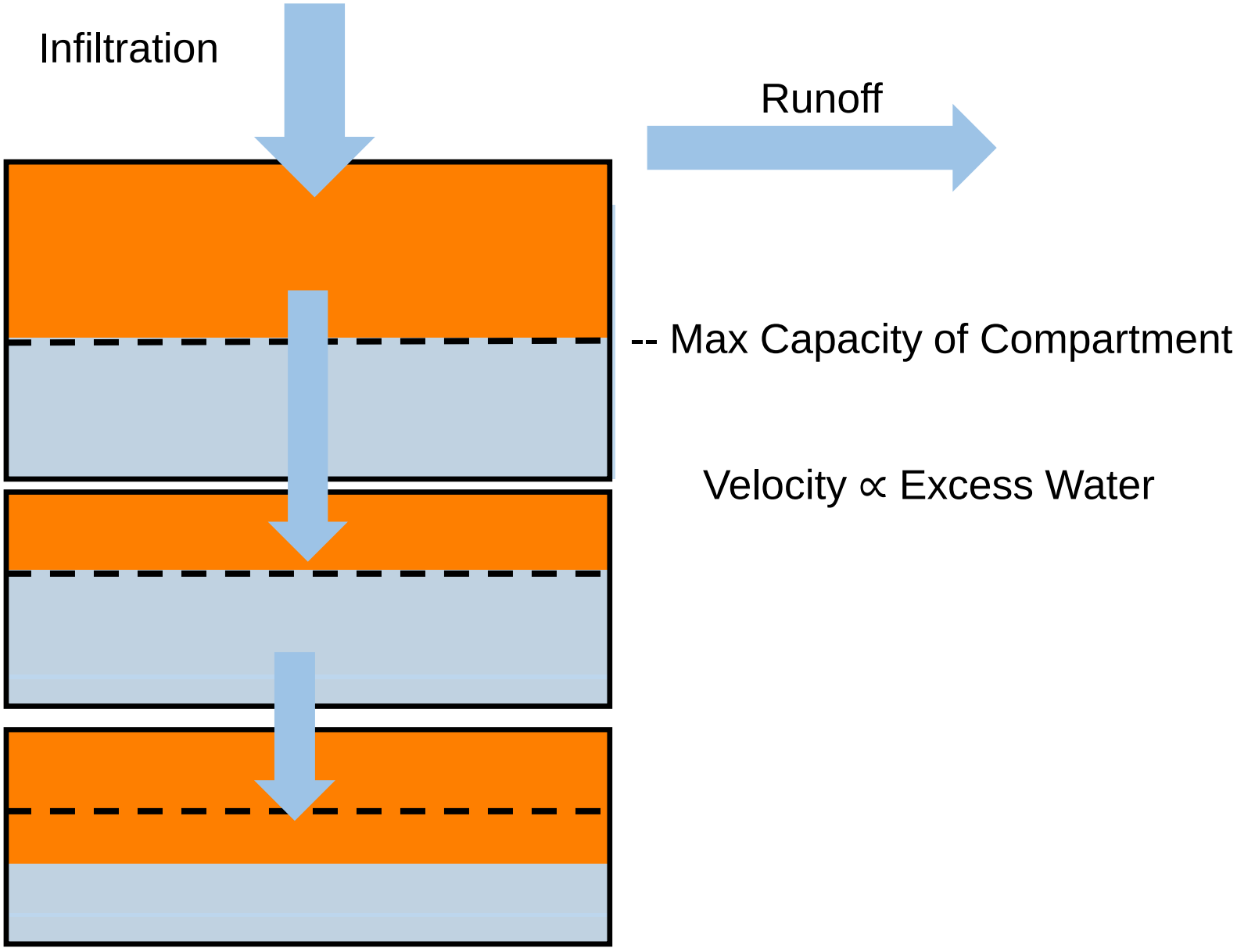
Profile divided into homogeneous layers



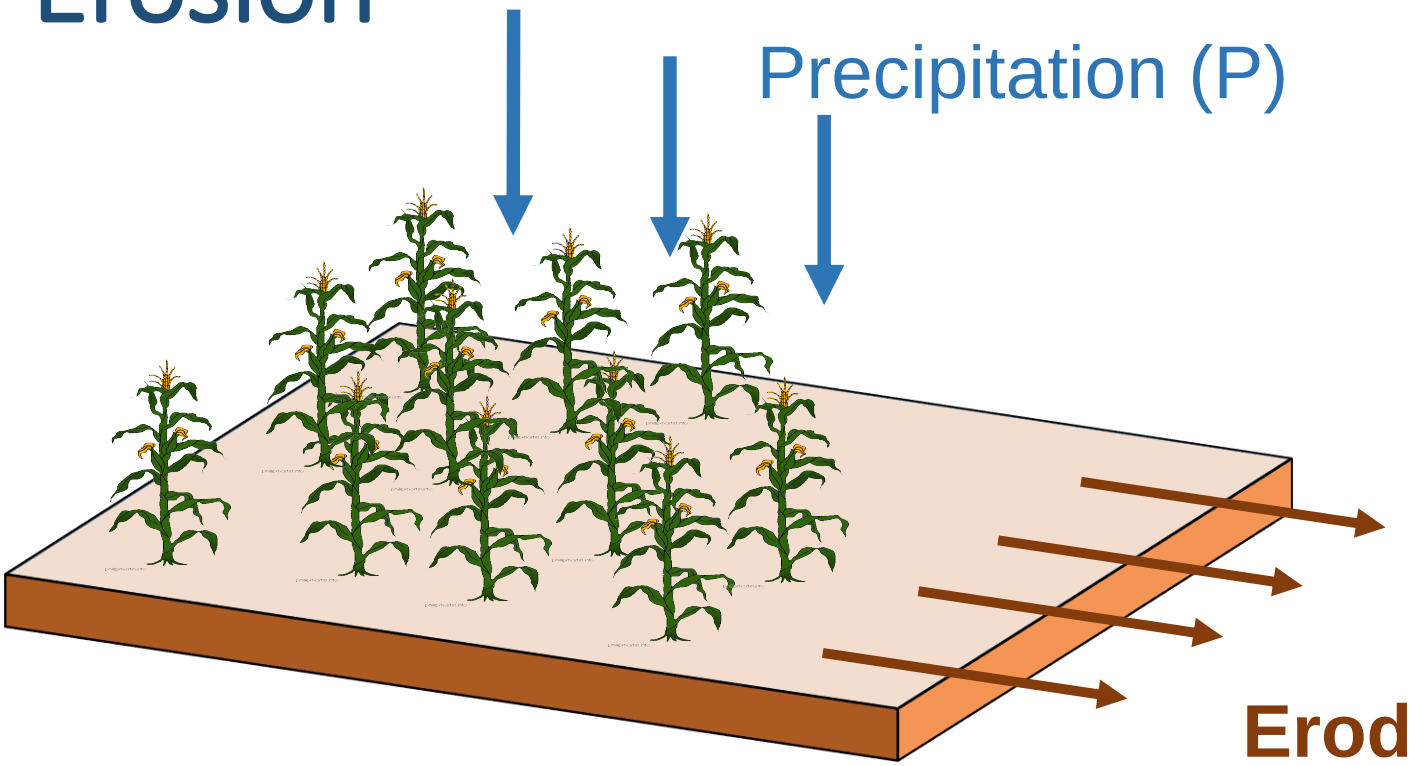
Each layer characterized by:

- -Size
- -Water Holding Capacity
- -Organic Carbon
- -Number of numerical discretizations*
- -bulk density

Vertical Water Movement: Capacity Model



Erosion



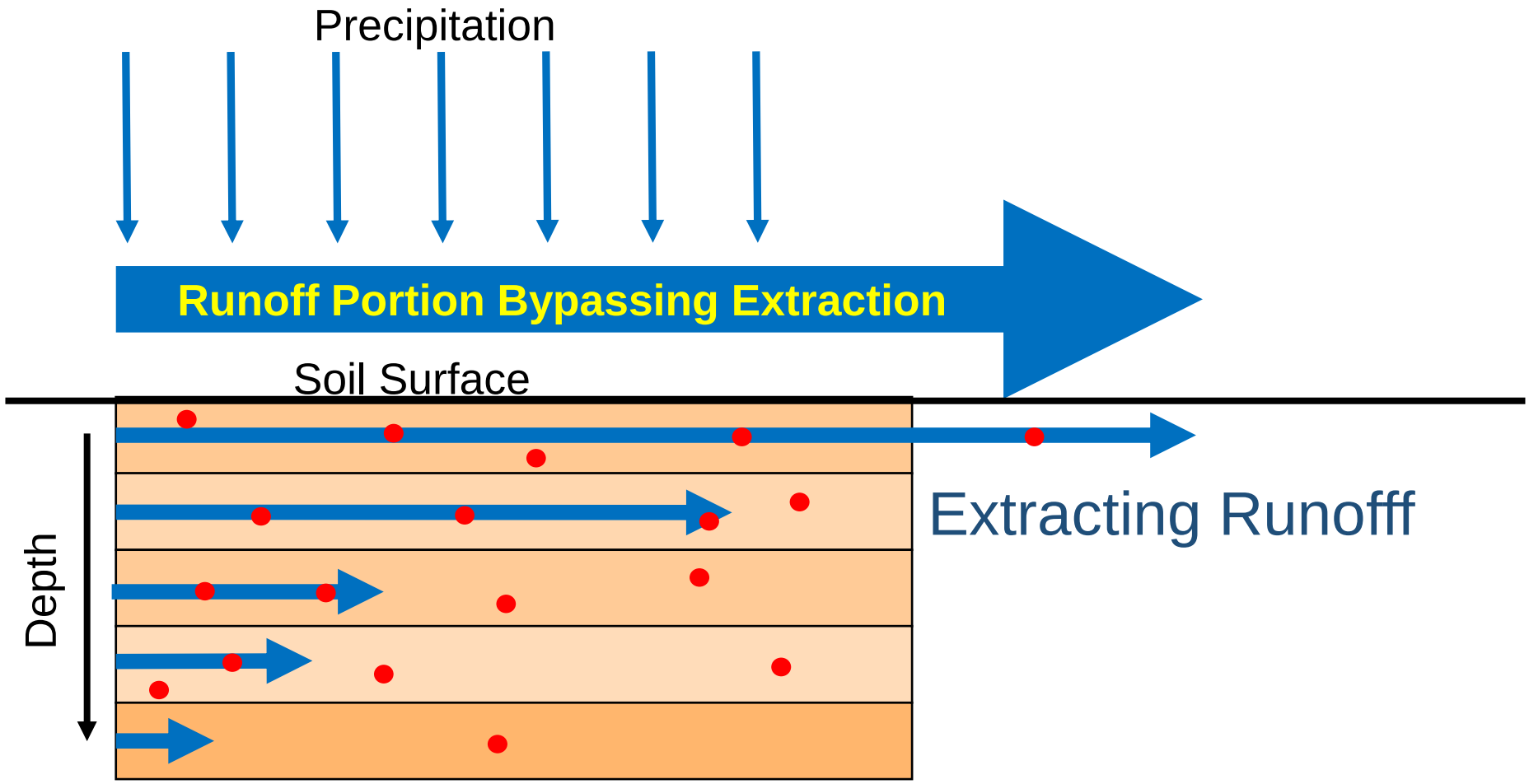
MUSS Equation

Mass $=0.79(R * q_p)^{0.65} * A^{0.009} * LS * C * P$

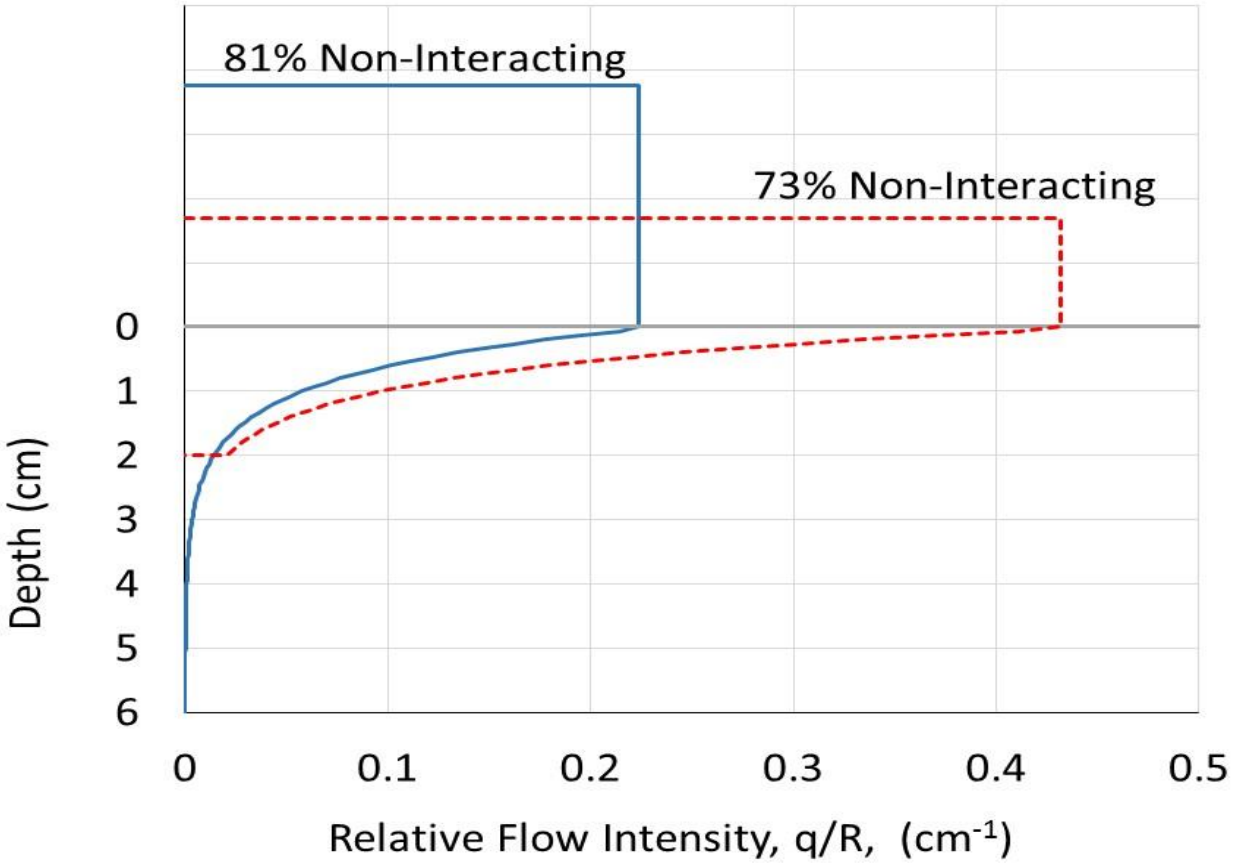
-- Designed for very specific knowledge of a particular field
-- Highly complex & detailed parameter calculations (ref. RUSLE2)
-- Regulatory applications are not so specific

Runoff Extraction of Pesticide

Hypothetical Subsoil Runoff Distribution &
Corresponding Extraction Potential
Newly calibrated per Young and Fry (2017)



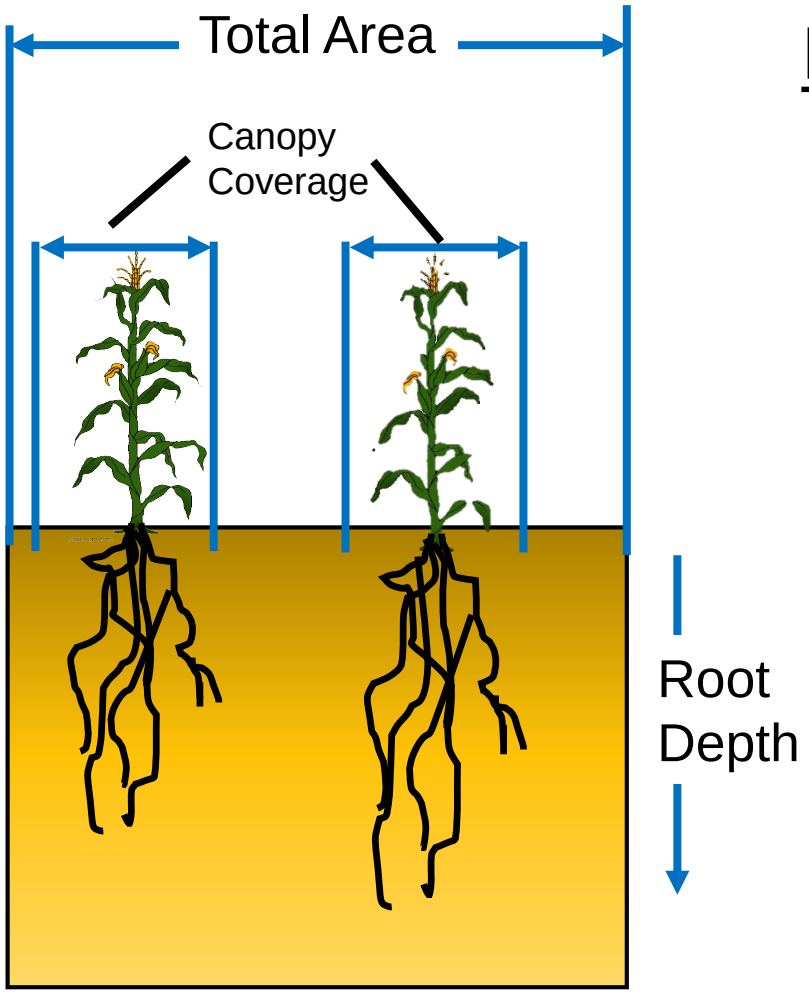
New Calibrated Runoff Extraction Profile for PWC



Young and Fry (2017) *Env. Modeling & Software, doi.org/10.1016/j.envsoft.2017.09.007*

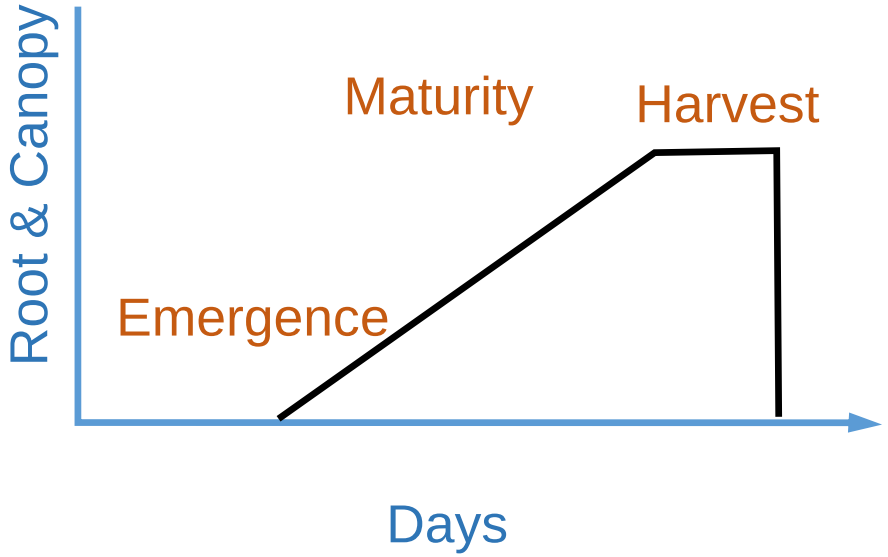
Part 3a:
Field Crop Growth

General Crop Growth in PWC

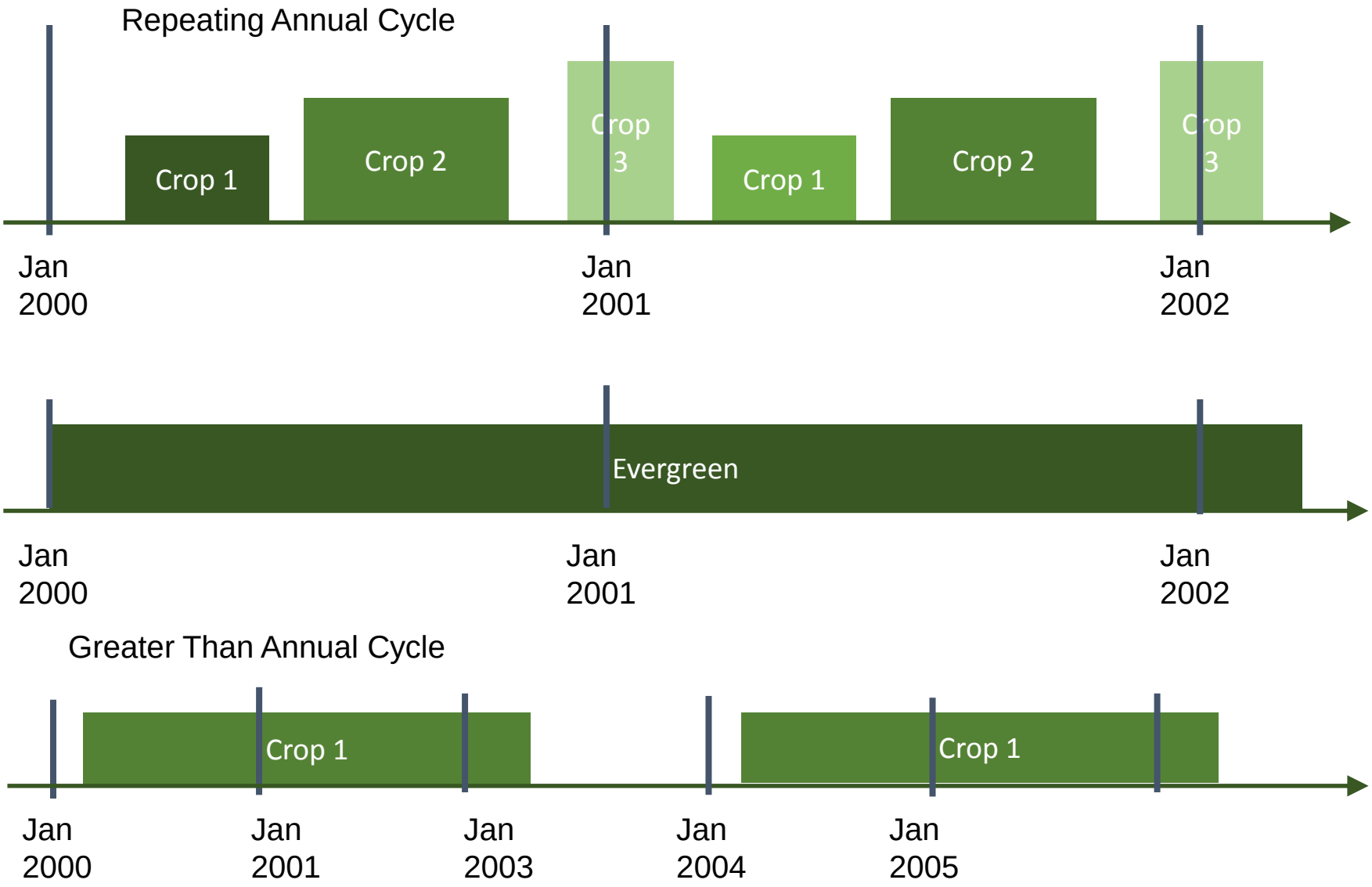


Plant Characteristics Modeled:

Root depth
Canopy Coverage

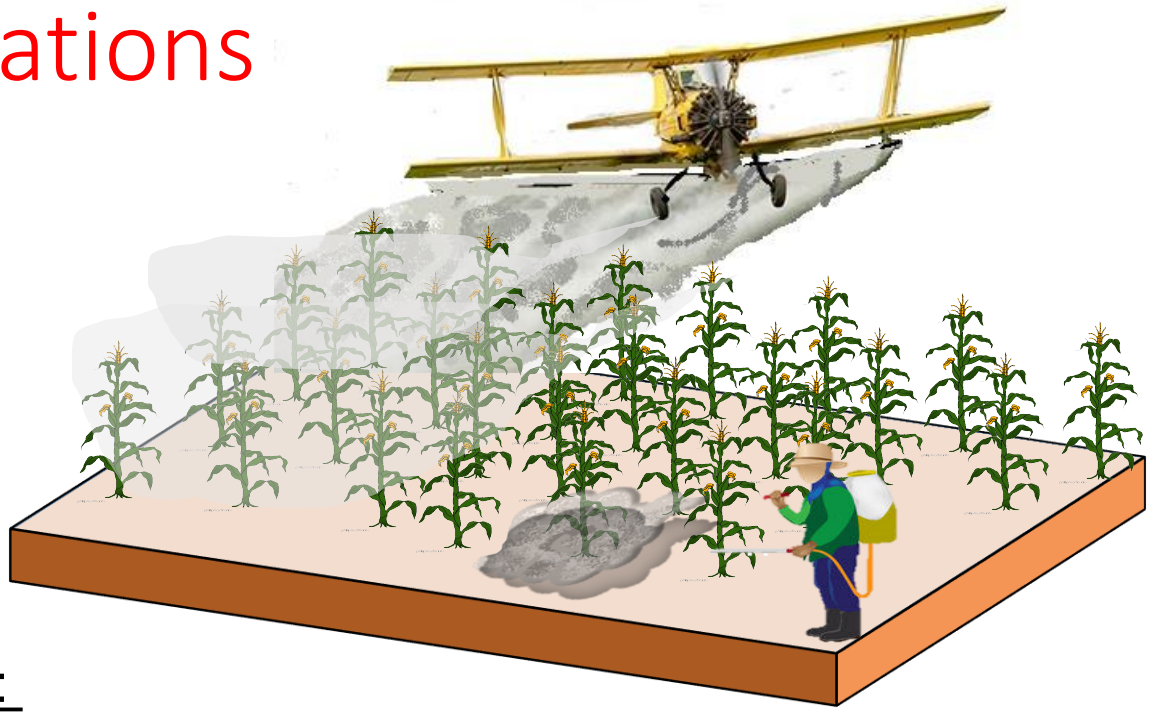


Planting Cycles Available in PWC



Part 3b:
Pesticide Processes

Pesticide Applications

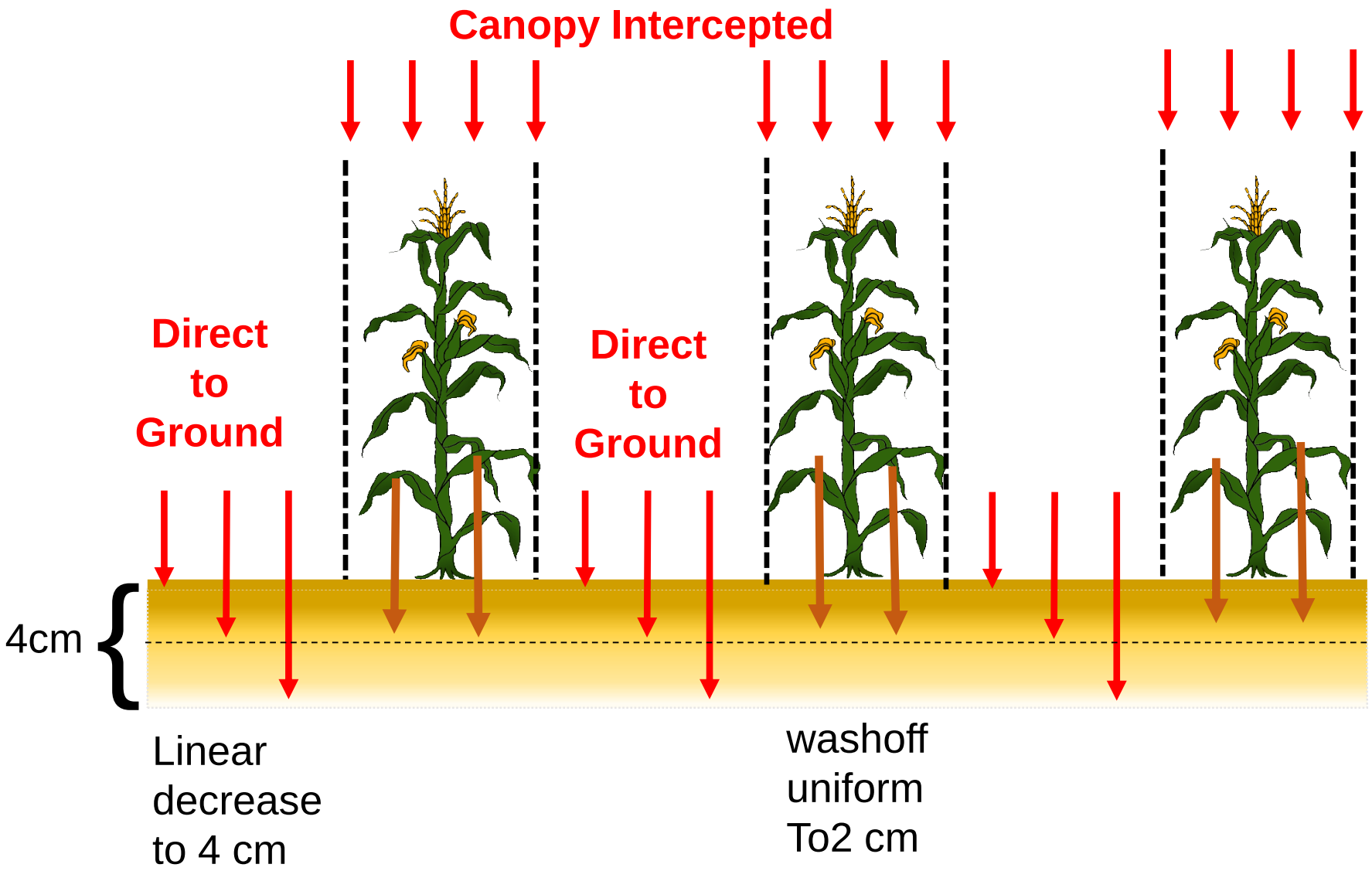


2 Broad Division of Methods:

To Canopy: Will initiate foliar processes: washoff & foliar degradation

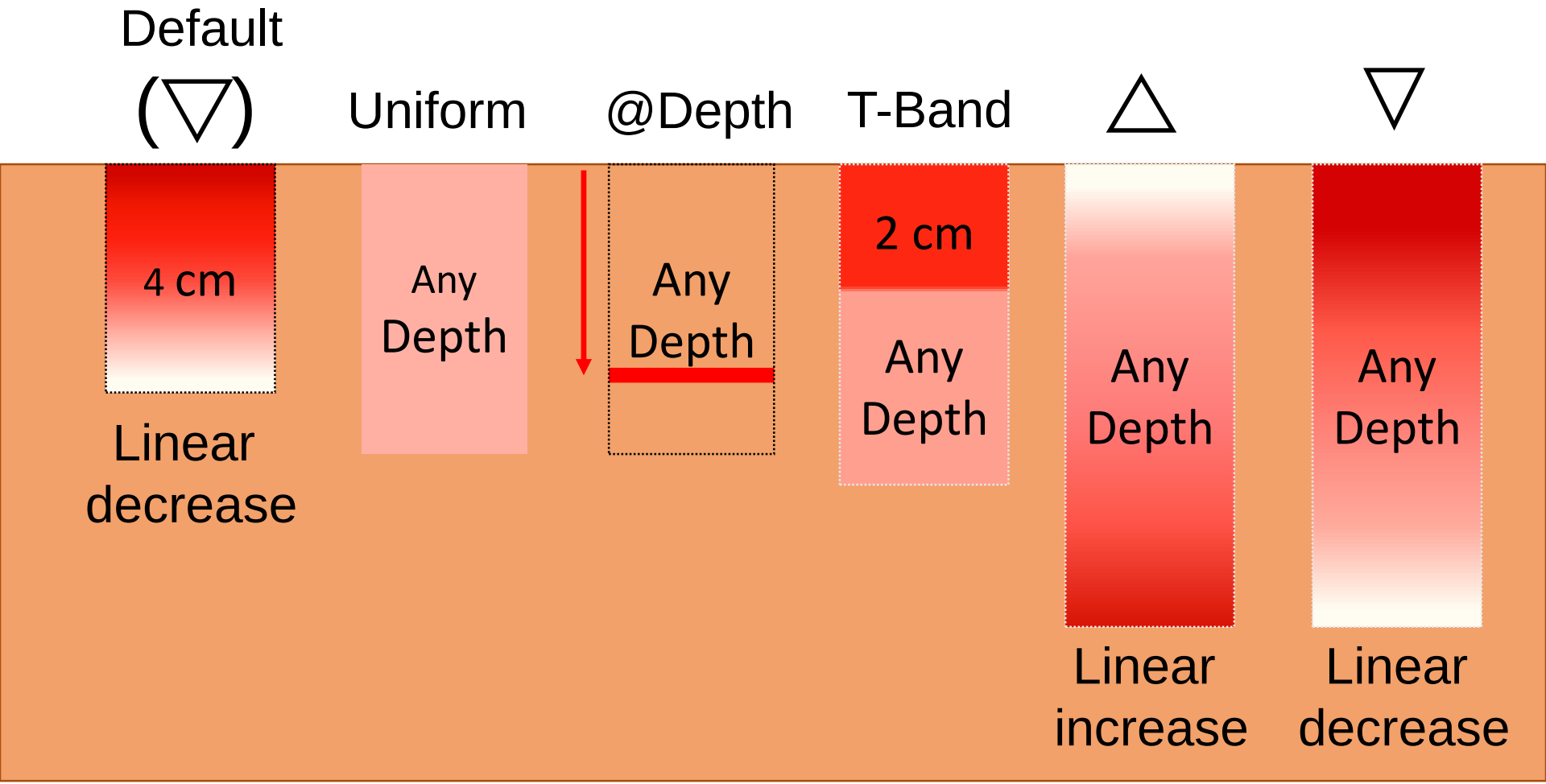
Below Canopy: Ground Applications, Seed Treatments, Incorporations, etc
More Specific Method Available

Pesticide Applications: Above Canopy

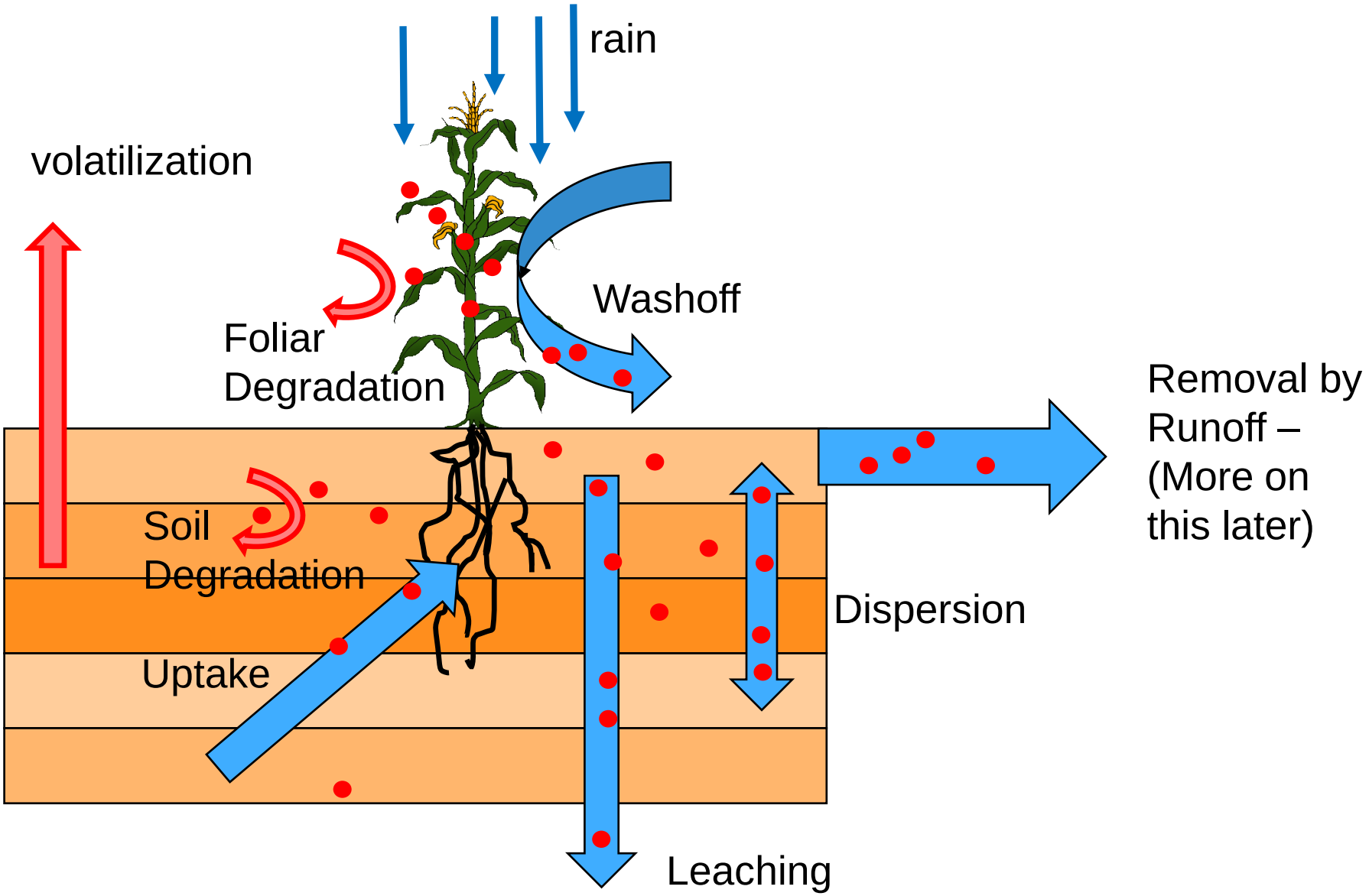


Pesticide Applications: Below Canopy

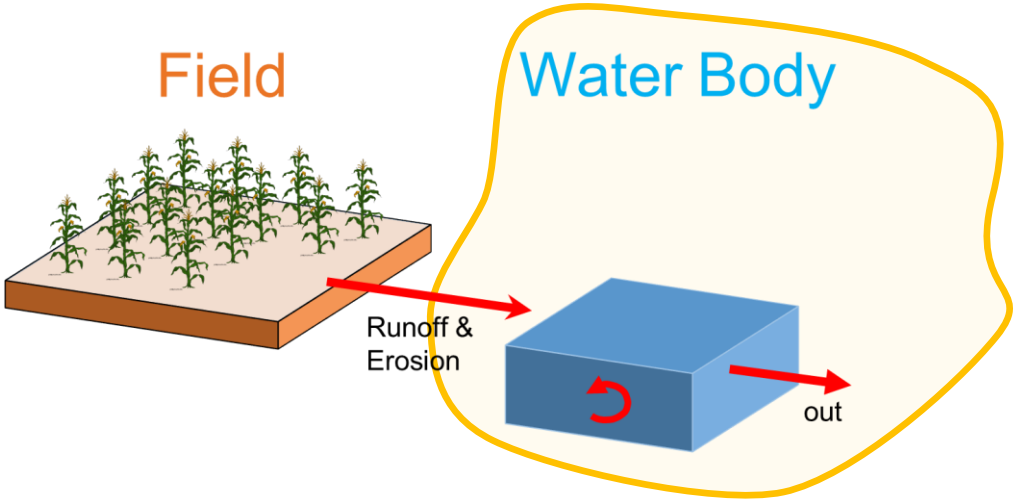
In-Ground Pesticide Distribution Profiles Available in PWC



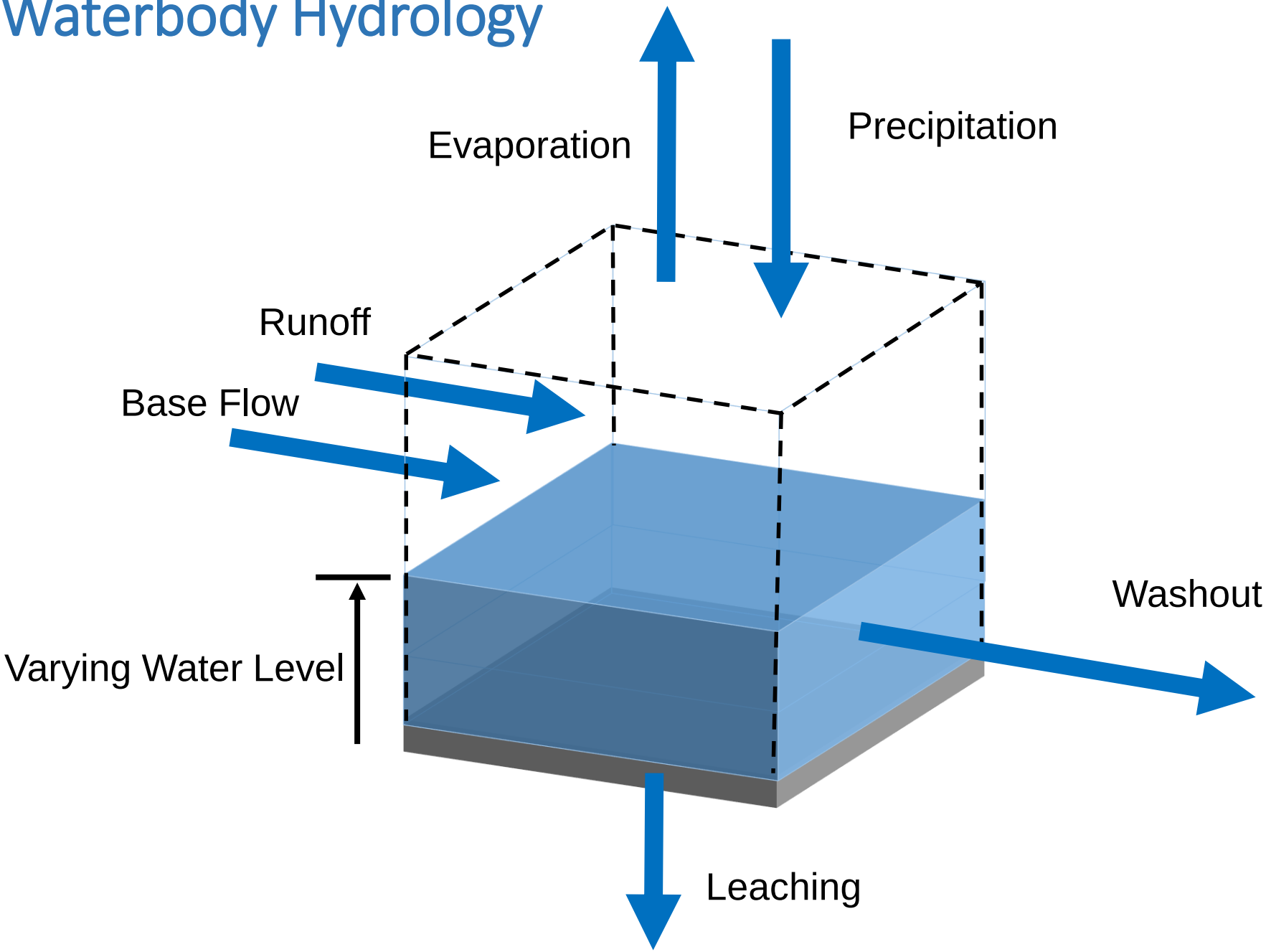
Pesticide Processes Overview



Part 4:
Waterbody Hydrology & Chemical Fate

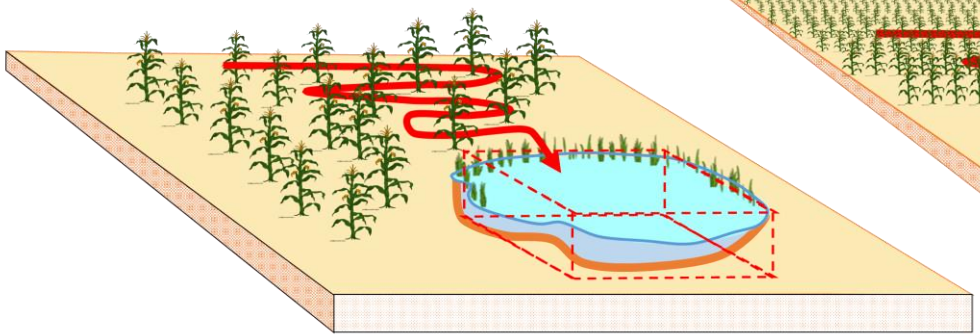


Waterbody Hydrology

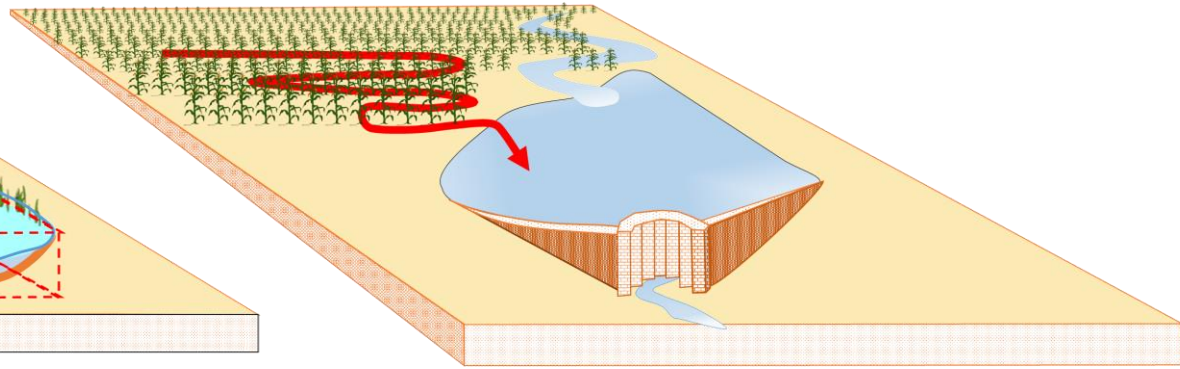


PWC can simulate many water body types

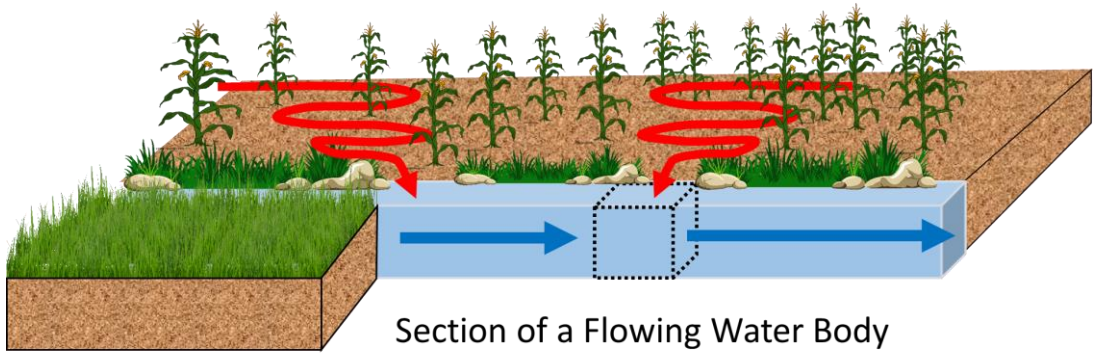
Confined Pond



Flow-Through Reservoir

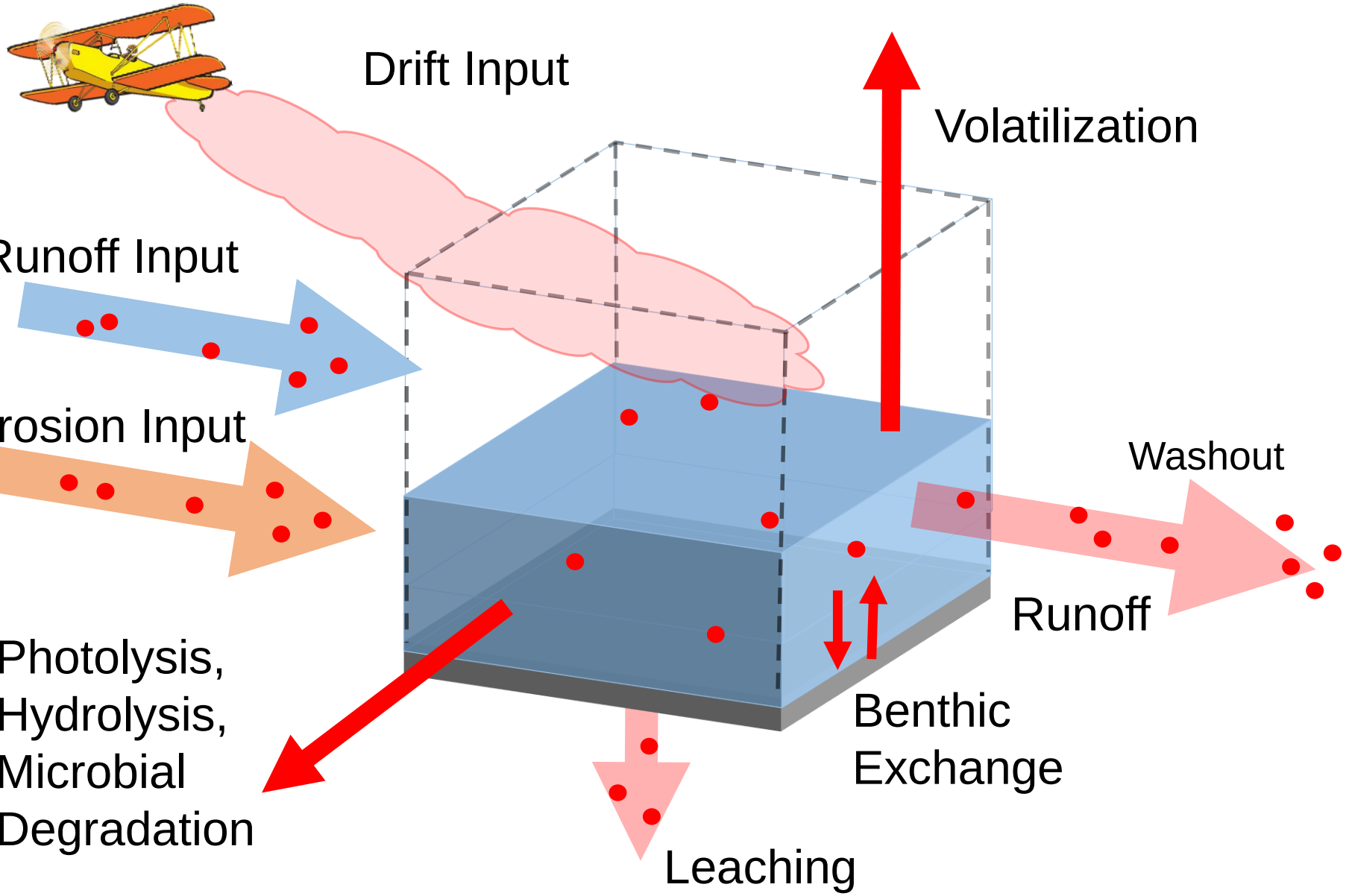


Flowing Water

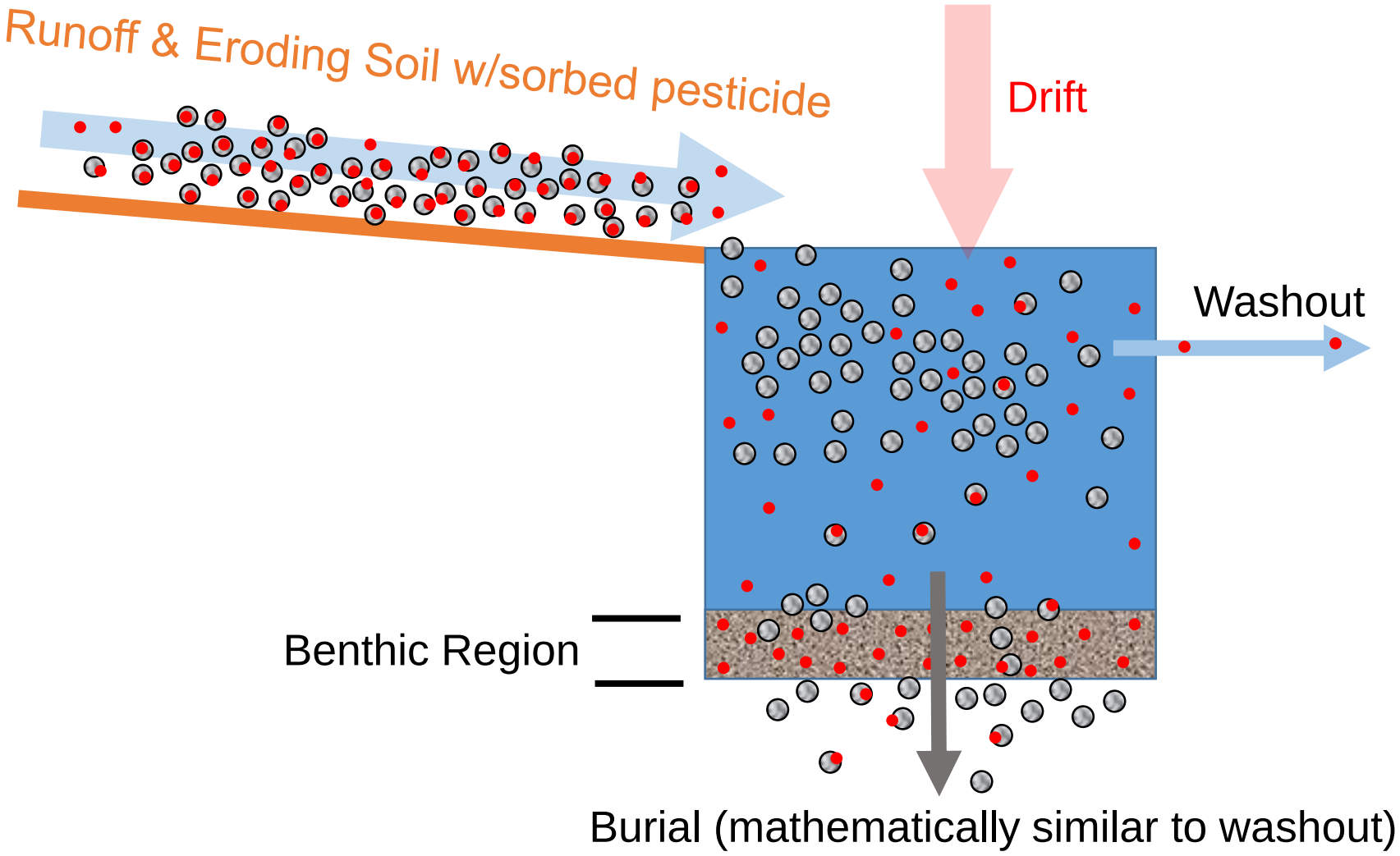


Section of a Flowing Water Body

Pesticide Processes in Waterbody



Handling Pesticide Input to the water body

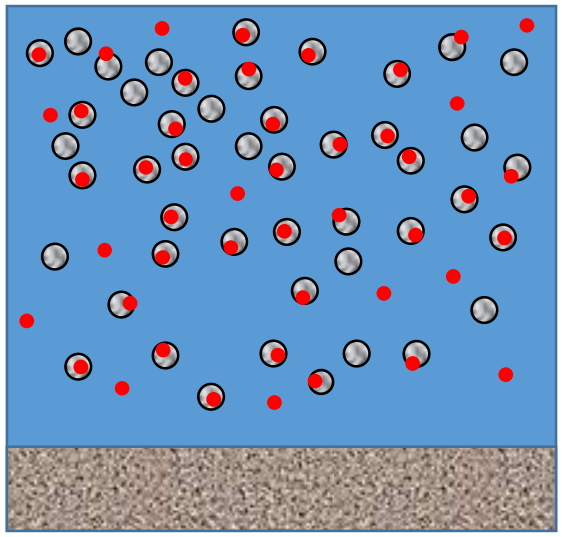


Daily Settling (No mechanistic particle dynamics)

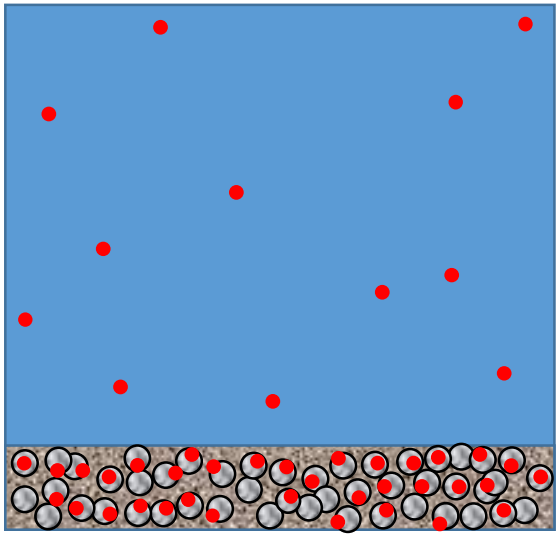
1. Equilibrate: pesticide with water & Suspended Solids

2. Distribute: dissolved to water column & sorbed to benthos

Equilibrate



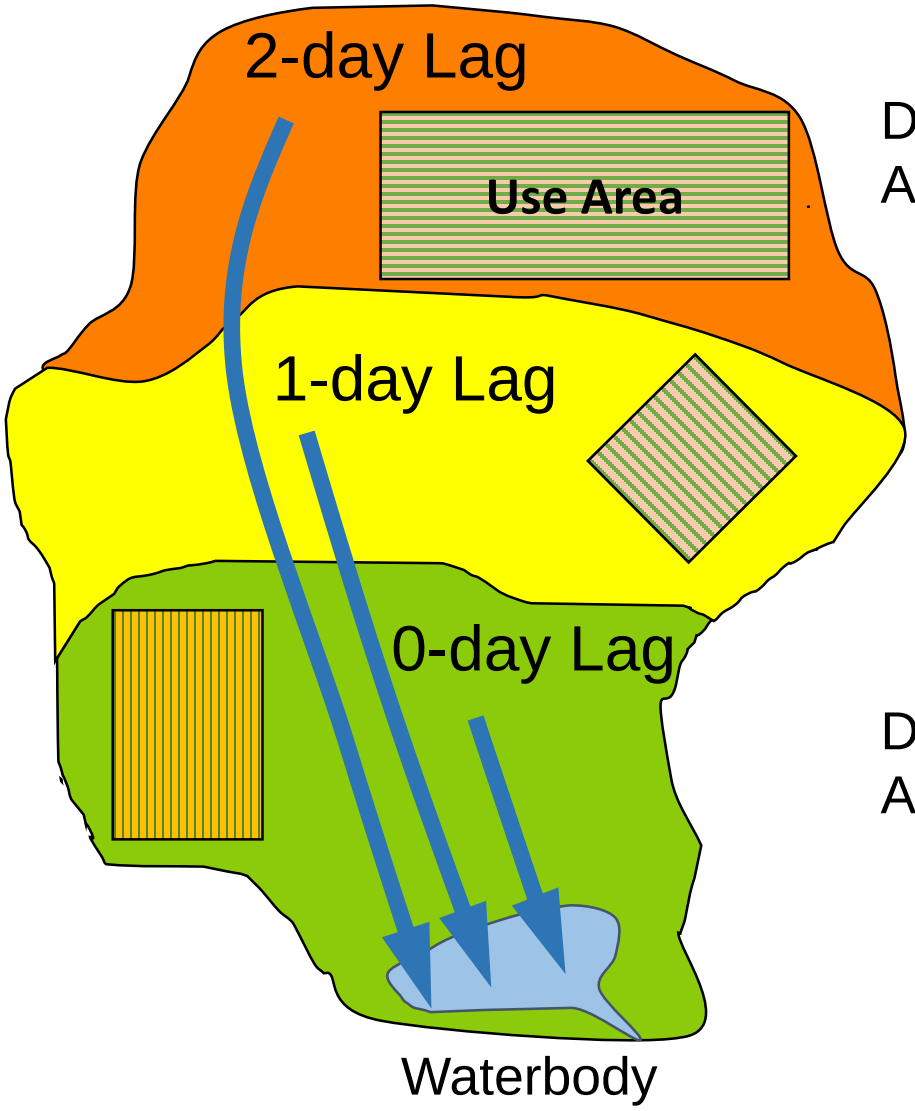
Distribute



Part 5:
Addressing Large Watersheds

-- A New Addition to the PWC --

Larger Watershed –Delayed Responses



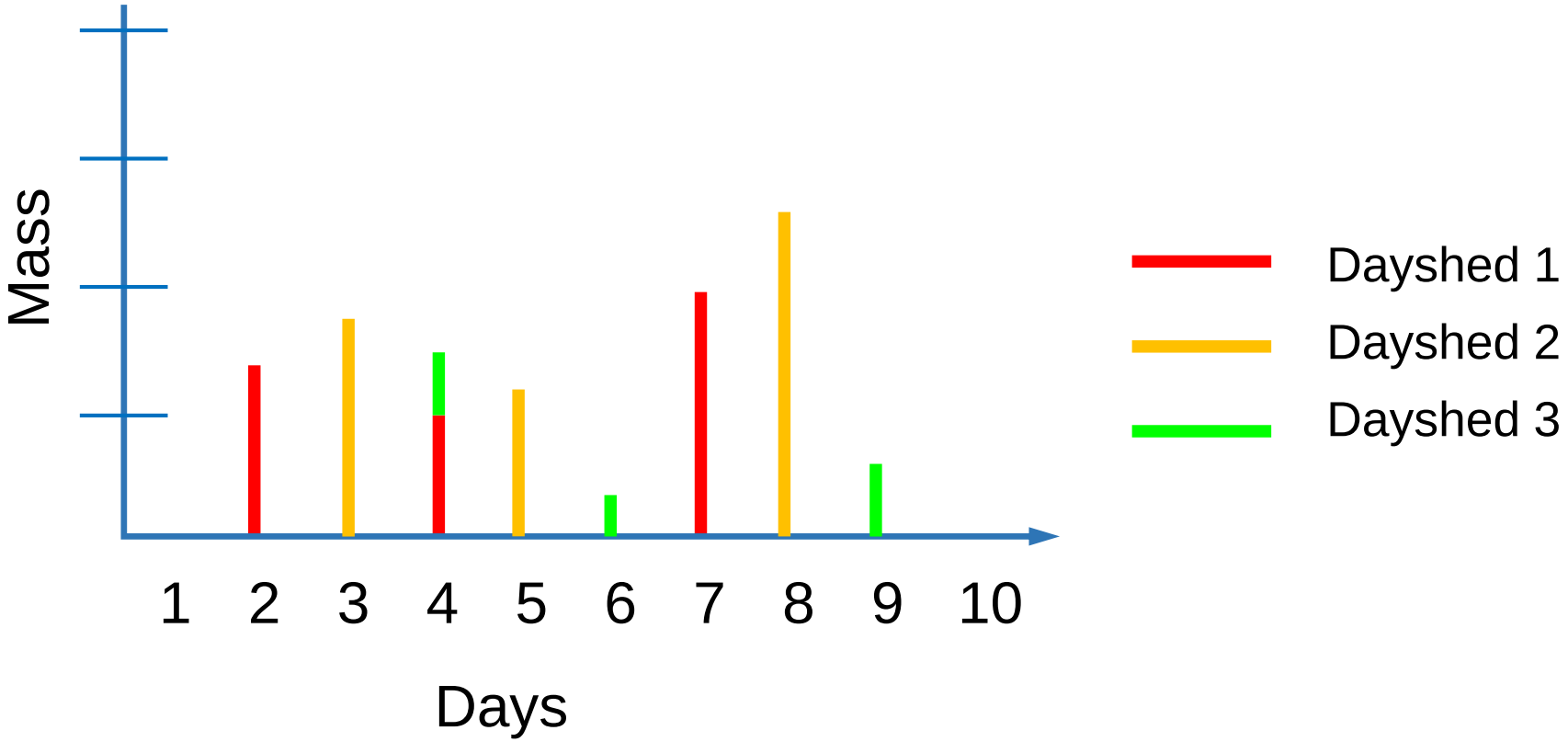
Dayshed$_2$: Lag Time = 2 days
A_2, PCA_2

Dayshed$_1$: Lag Time = 1 day
A_1, PCA_1

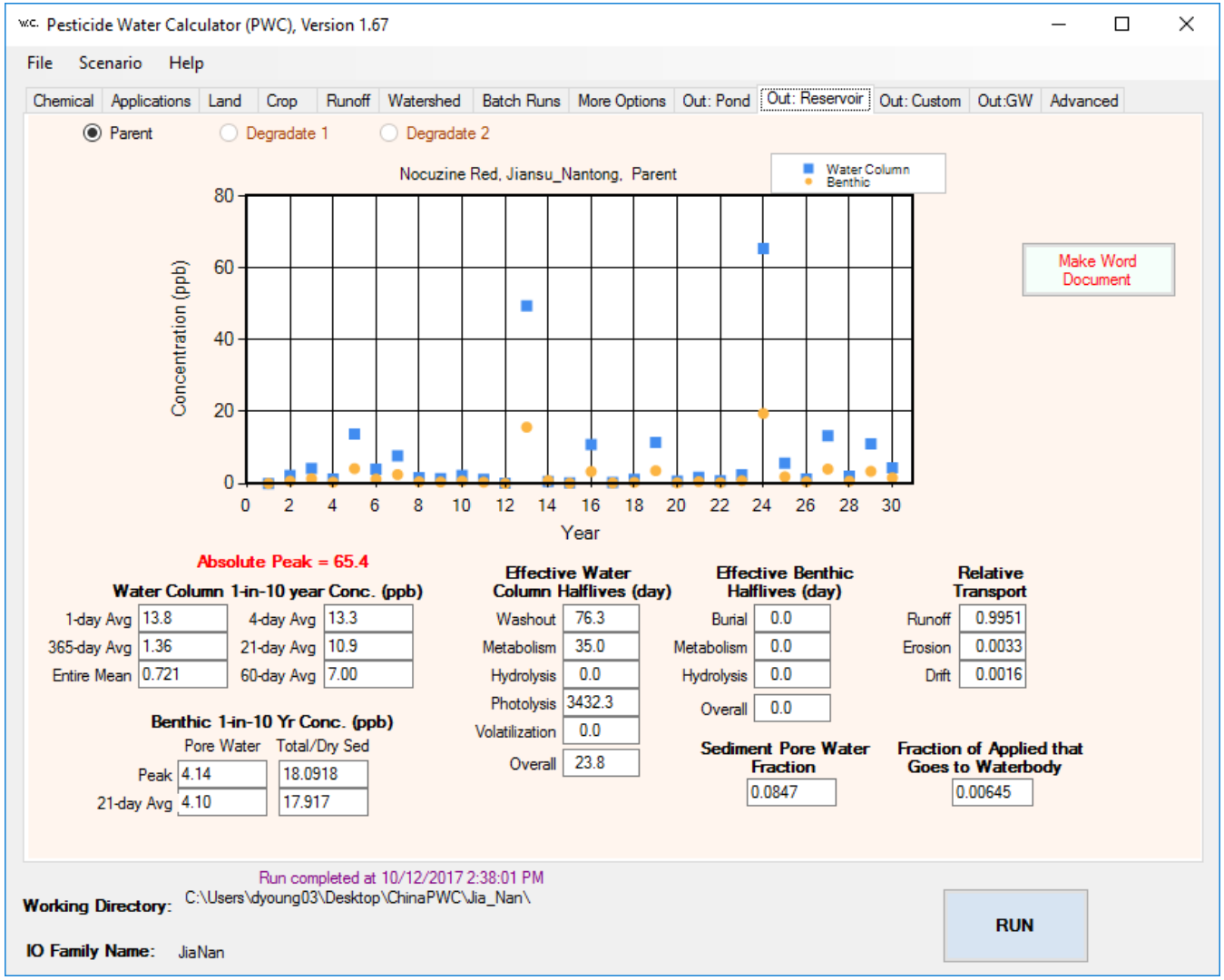
Dayshed$_0$: Lagl Time = 0 days
A_0, $PCA_{0,}$

A = Area
PCA = Percent Cropped Area

Total Watershed Response by Superimposition



RESULTS: PWC Output



The End

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