Aquatic Endangered Species Assessment of Chlorpyrifos: 2. Screening Level Exposure Modeling, Action Area Definition, and Co-occurrence

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August 18th, 2015

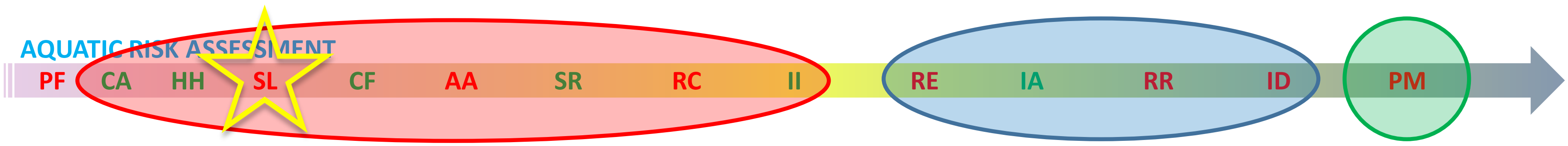
250th American Chemical Society National Meeting & Exposition

Boston, Massachusetts

Step 1 of the Chlorpyrifos (CPY) National Aquatic Endangered Species Assessment

Following the Croplife America framework, a screening level ecological risk assessment occurs in Step 1 to determine potential risk to listed species.

- **Screening level aquatic exposure modeling (part of SLERA)**
- Aquatic action area definition
- Co-occurrence analysis



"Step 1"

CA	County-level co-occurrence analysis
HH	HUC2 and habitat bin assignments
SL	Screening-level ecological risk assessment (SLERA)
CF	Crop footprints
AA	Action area delineation
SR	Species ranges
RC	Refined co-occurrence analysis
II	Initial IMS assessment

"Step 2"

RE	Refined exposure analysis
IA	Advanced IMS assessment
RR	Registrant report
ID	Final IMS documentation

"Step 3"

PM	Population modeling

Screening Level Aquatic Exposure Modeling: Approach

Follow proposed US EPA/Services aquatic modeling methods (Peck et al., 2015)

- Simulate generic aquatic habitats ("bins")
- Use current US EPA regulatory models (AgDRIFT, PRZM, VVWM)
- Represent pesticide uses by aggregated "crop groups" (e.g., orchards/vineyards)
- Apply existing US EPA standard crop scenarios
- Parametrize each scenario conservatively based on nationally available datasets
- Estimate exposure for each crop group/HUC2/habitat combination

Aquatic endangered species are mapped to relevant HUC2/habitat combinations

Exposure estimates are compared with relevant screening level effects metrics

Screening Level Aquatic Exposure Modeling: Generic Habitat Bins

Ten generic aquatic habitat bins have been proposed by US EPA/Services (Peck et al., 2015)

Generic Habitat	Depth (meters)	Width (meters)	Length (meters)	Flow (m^3/s)
1 – Aquatic-associated terrestrial habitats	NA	NA	NA	NA
2- low-flow	0.1	2	Length of field[1]	0.001
3- Moderate-flow	1	8	Length of field	1
4- High-flow	2	40	Length of field	100
5 – Low-volume	0.1	1	1	0
6- Moderate-volume	1	10	10	0
7- High-volume	2	100	100	0
8- Intertidal nearshore	0.5	50	Length of field	NA
9- Subtidal nearshore	5	200	Length of field	NA
10- Offshore marine	200	300	Length of field	NA

From Peck et al., 2015

Due to their complexity, marine habitats will not be addressed at this time.

Results and challenges will be presented for static and flowing water habitat bins.

Screening Level Aquatic Exposure Modeling: Models

AgDRIFT 2.1.1:

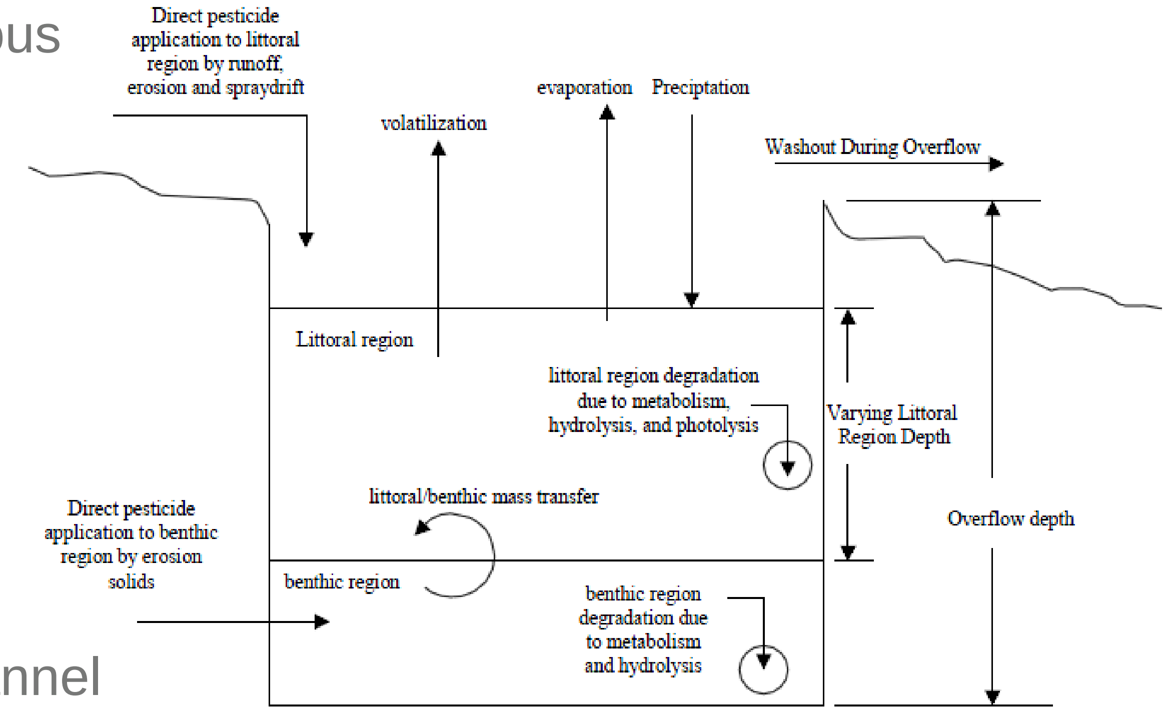
- CPY has existing buffers depending on application method (25 ft. – 150 ft.)
- Drift fractions calculated based on required setback and habitat dimensions

PRZM5:

- Latest regulatory version of the Pesticide Root Zone Model included with the Surface Water Concentration Calculator (SWCC)
- Simulates a single homogeneous field

VVWM:

- Replacement for EXAMS, part of SWCC
- Simulates a water body with optional flow-through
- Conceptualized as a reservoir with overflow rather than a channel



From Young, 2014

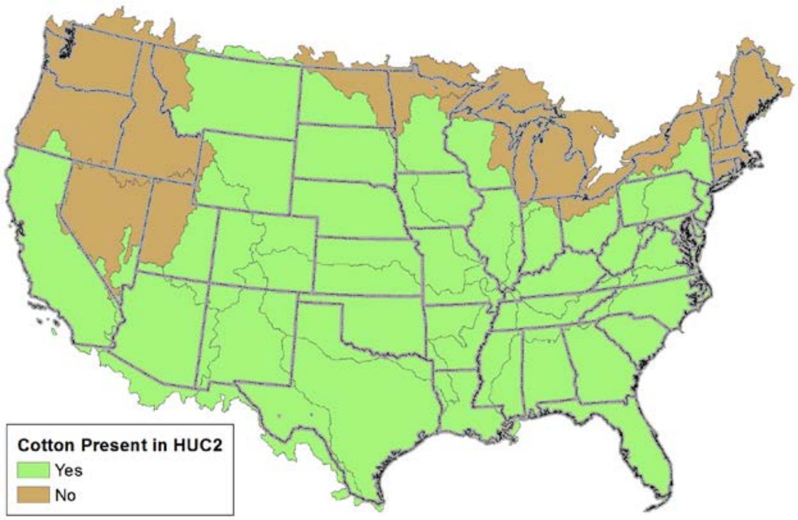
Screening Level Aquatic Exposure Modeling: CPY Crop Groups

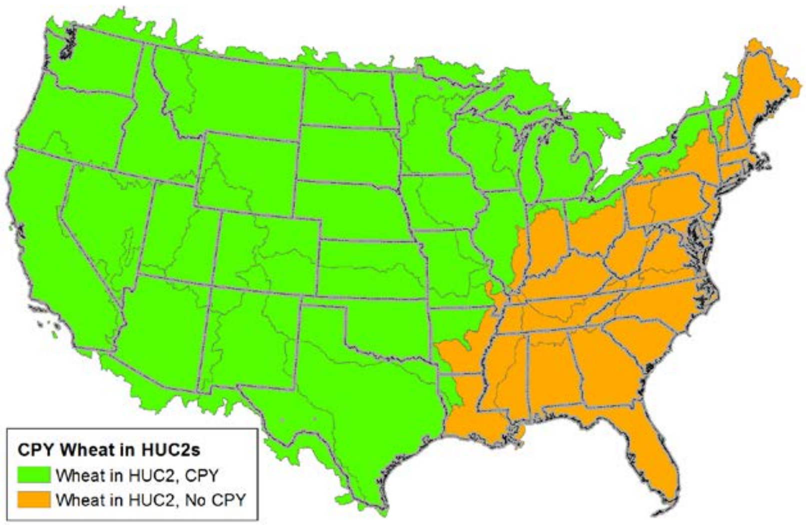
Custom CPY crop groups were developed based on current labels

- Out of 11 agricultural crop groups, CPY applied to 10
- Corn, cotton, orchard/vineyard, other crops, other row crops, pasture/hay, soybeans, vegetables and group fruit, other grains, wheat

Cropland Data Layer (CDL) crop group presence in HUC2s indicated if a crop group PRZM scenario was required

CPY label geographic use restrictions further constrained relevant PRZM scenarios



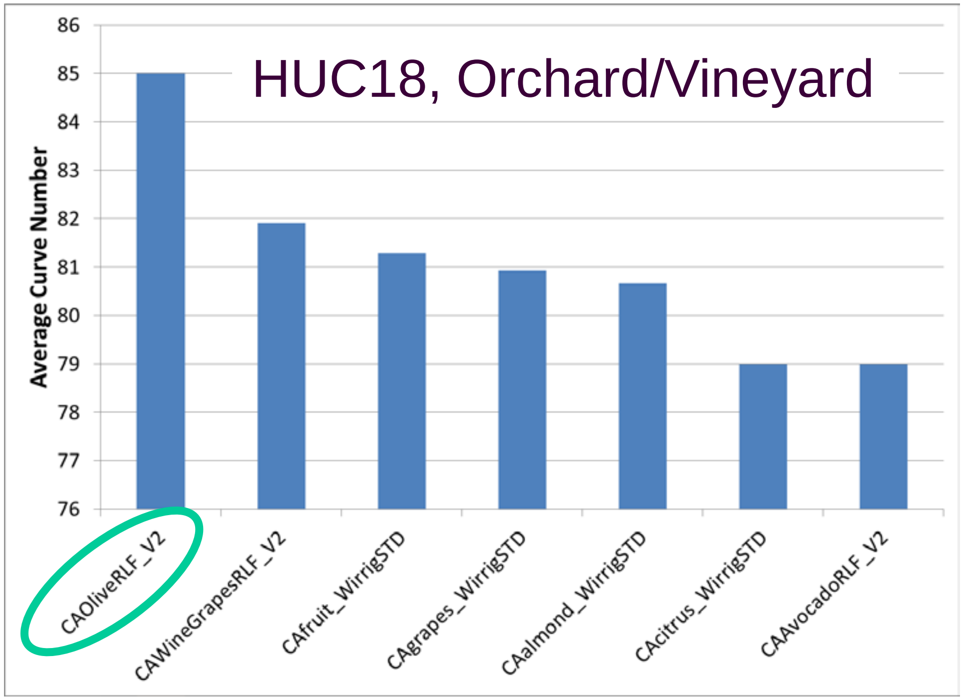


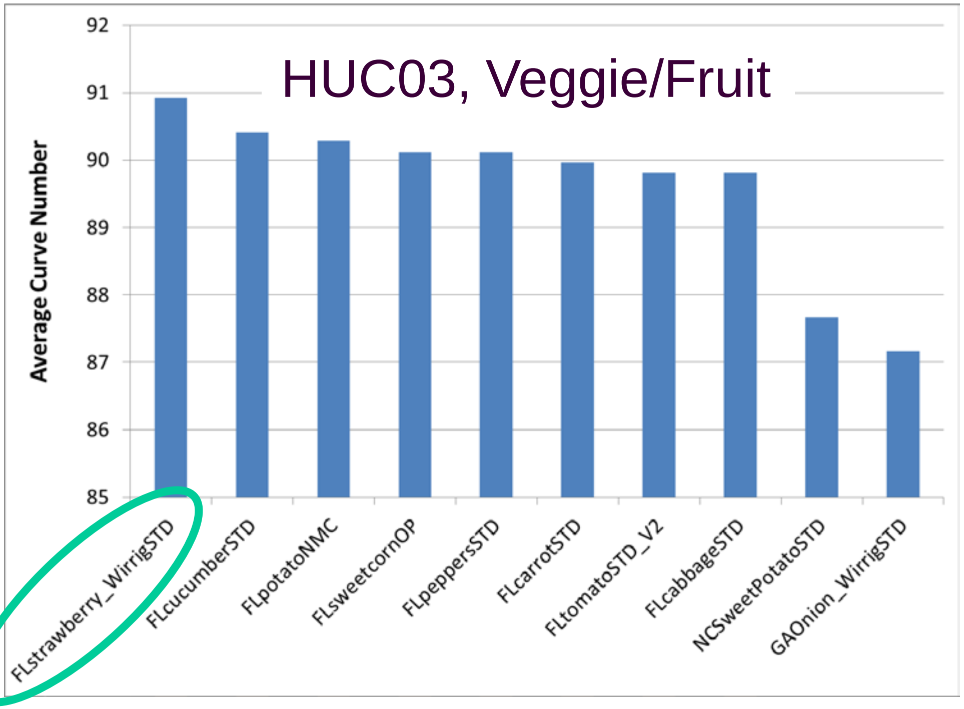
Screening Level Aquatic Exposure Modeling: Identify Representative PRZM Scenarios

Existing PRZM standard scenarios mapped to each HUC2 and crop group

- Generally associated each scenario with 1 crop group
- For some cases, made an association between alike crop groups (e.g., corn/soybeans; wheat/other grains)

The most vulnerable scenario in each HUC2/crop group was determined based on average annual curve number





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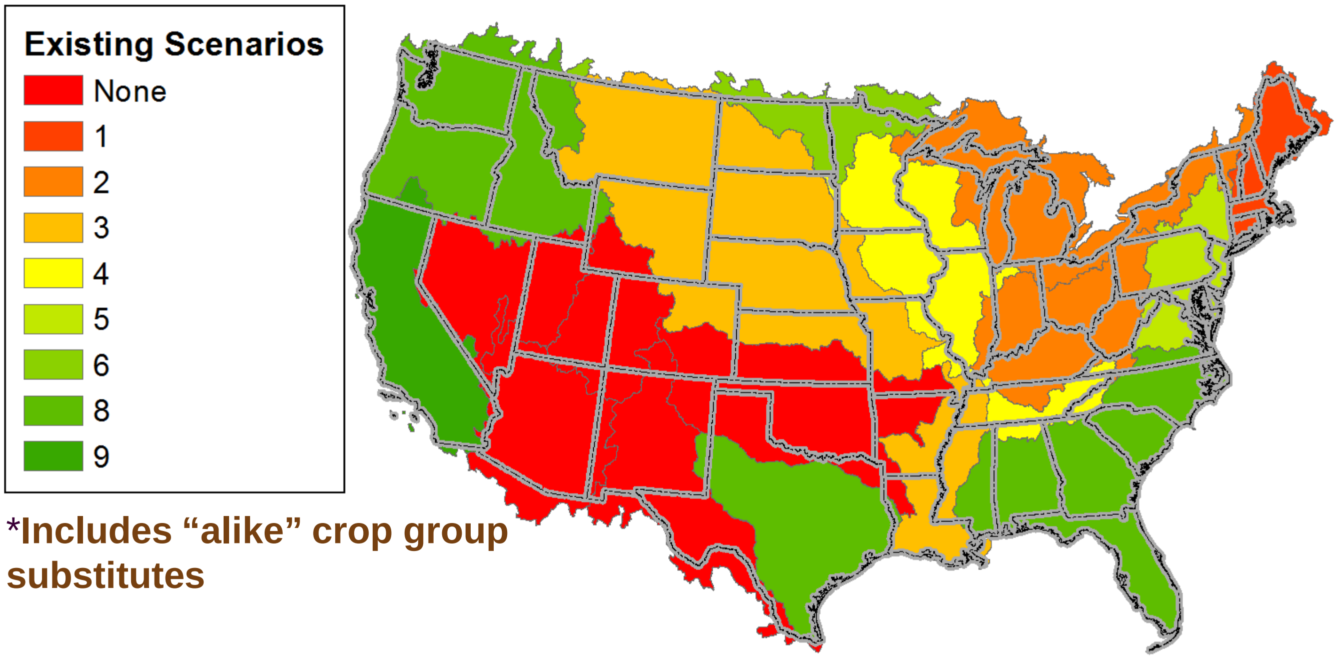
Screening Level Aquatic Exposure Modeling: Identify Representative PRZM Scenarios, Cont.

Existing PRZM standard scenarios do not exist for many HUC2/crop group combinations (for CPY, 9 to 10 are needed per HUC2)



***Includes “alike” crop group substitutes**

Surrogate scenarios were identified for HUC2/crop groups without existing scenarios based on proximity.

- Existing scenario location based on standard weather station lat/long
- Proximity calculated as distance from weather station to HUC2 boundary
- Existing scenarios from either the “target” or ”alike” crop group were eligible

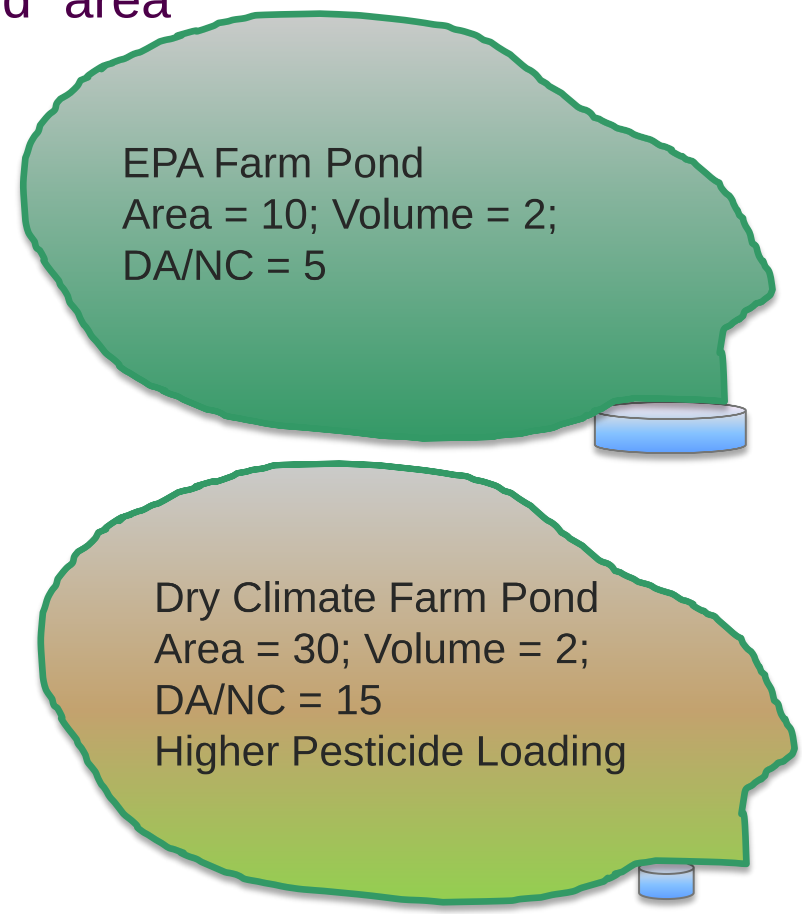
Screening Level Aquatic Exposure Modeling: Parameterization of Static Water Habitats

Most of the critical parameters in US EPA's proposed approach for static water habitats are well defined in previously released materials (Peck et al., 2015)

- Water body depth, width, length

One key parameter requiring definition is the "field" area

- The US EPA "farm pond" scenario (used in ecological risk assessments required under FIFRA), assumes a drainage area to normal capacity ratio (DA/NC) of 5 and a drainage area to water body area ratio (DA/WA) of 10
- Indications are that the DA/NC ratio for US EPA's generic static habitats will vary geographically based on climate over a range of 5 to 15
- For a given climate, larger field areas = higher pesticide loading

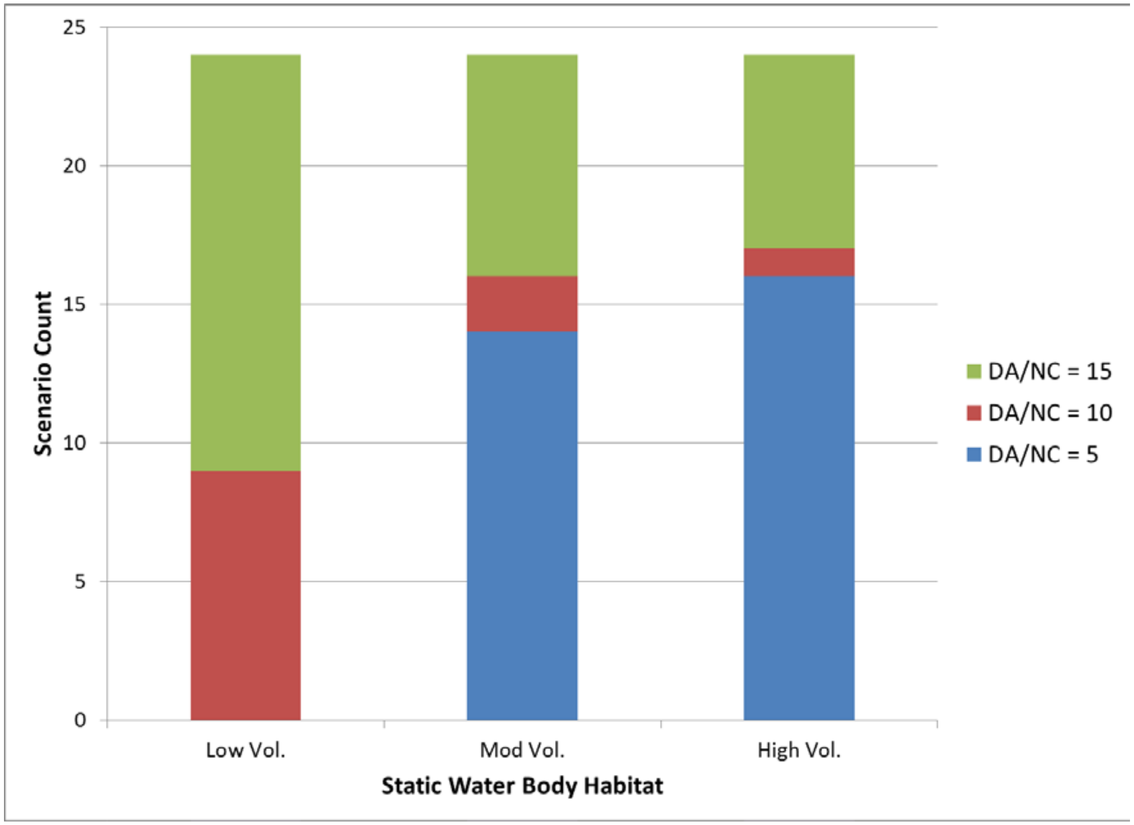


Screening Level Aquatic Exposure Modeling: Parameterization of Static Water Habitats, Cont.

The theory that larger field areas should be associated with drier climates was followed (lower precipitation = lower runoff = larger drainage area required to supply a "full" pond)

Field area required to generate runoff volume to offset (evaporation – precipitation) calculated based on:

- Average annual evaporation and precip. from PRZM met files
- Average annual runoff based on MS corn field characteristics
- E = P + (DA/WA)*R; where
  E = evaporation
  P = precip.
  R = runoff
  DA = drainage area
  WA = water body area
- Maximum DA/NC set at 15
- Minimum DA = 1 m^2



DA/NC > 5 is more conservative than standard farm pond

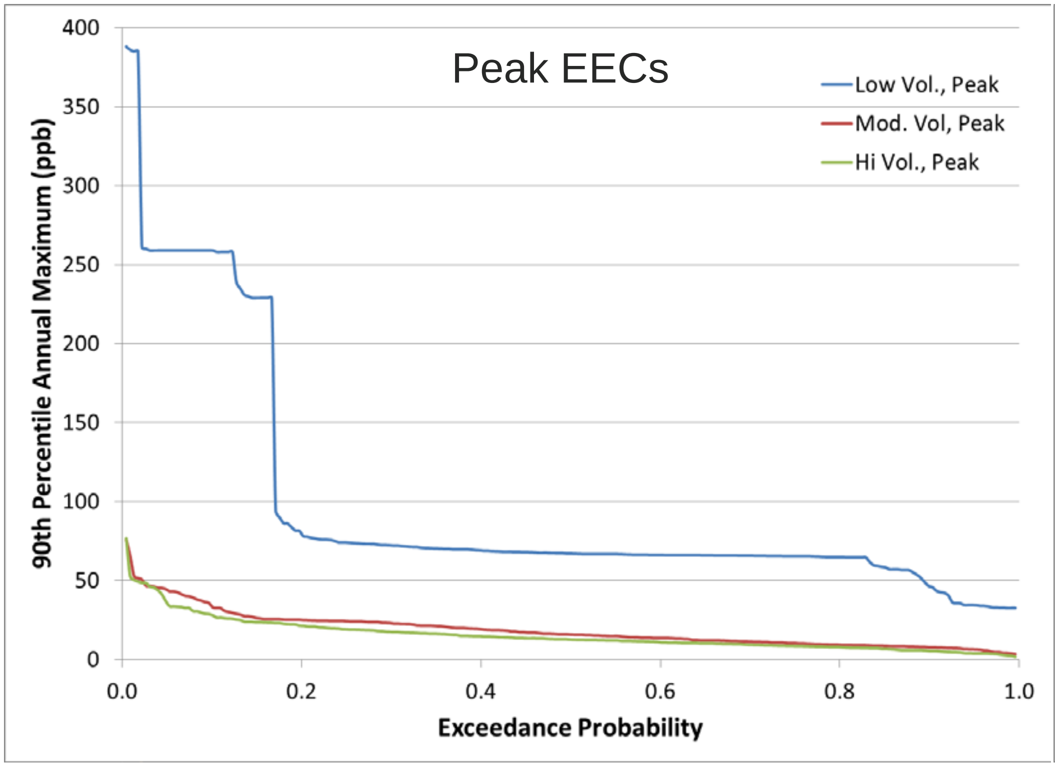
Screening Level Aquatic Exposure Modeling: Preliminary Exposure Results

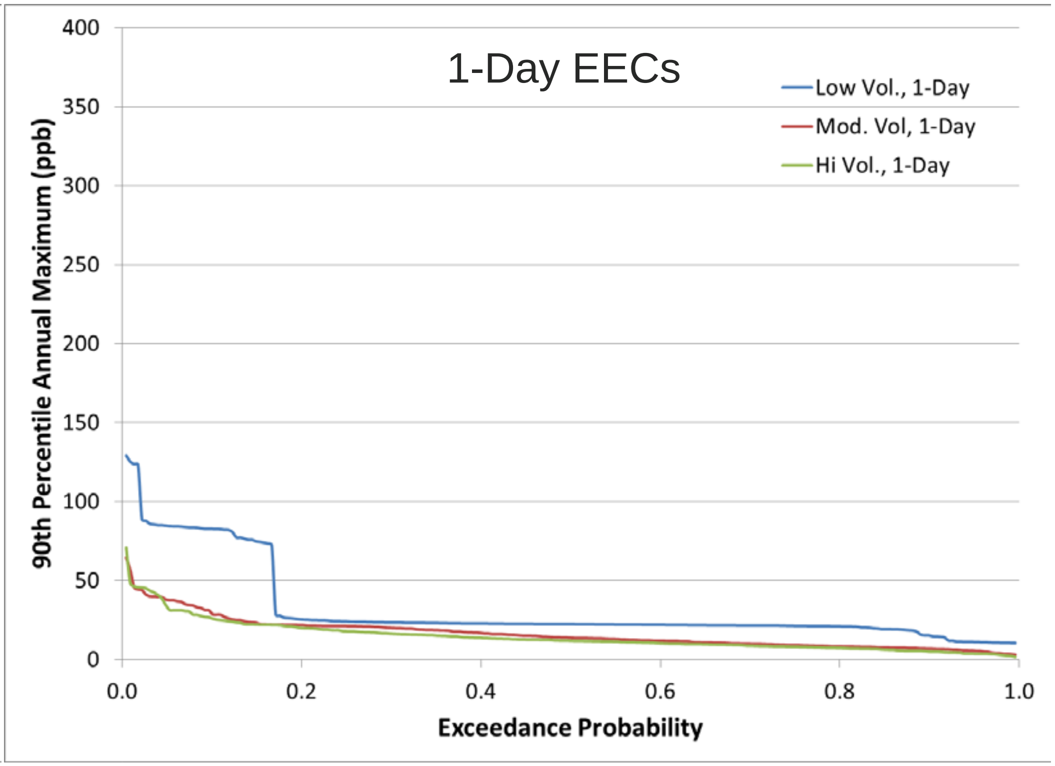
Conservative EECs generated for 227 scenarios and for 3 static water habitats

Low volume habitat is significantly more vulnerable than moderate/high volume

For low volume, instantaneous peak EECs are much higher than the 1-day EECs

Moderate and high volume EECs are similar for peak and 1-day





90th percentile annual maximum concentration distributions based on 227 crop group/weather/HUC2 scenarios per habitat bin

Screening Level Aquatic Exposure Modeling: Parameterization of Flowing Water Habitats

Several of the key parameters in US EPA's proposed approach for flowing water habitats have been provided in previously released materials (Peck et al., 2015)

- Water body depth, width, flow rate

Multiple critical parameters required for the flowing water scenarios have not yet been fully defined in public materials released through April of 2015

- Watershed area: General methodology for derivation from NHDPlus V2 provided
- Water body length: General methodology based on field area provided
- Flow through options:
  - Constant volume or variable volume
  - Constant flow rate or dynamic flow rate
  - Effective sedimentation rate (PRBEN)
  - Burial processes

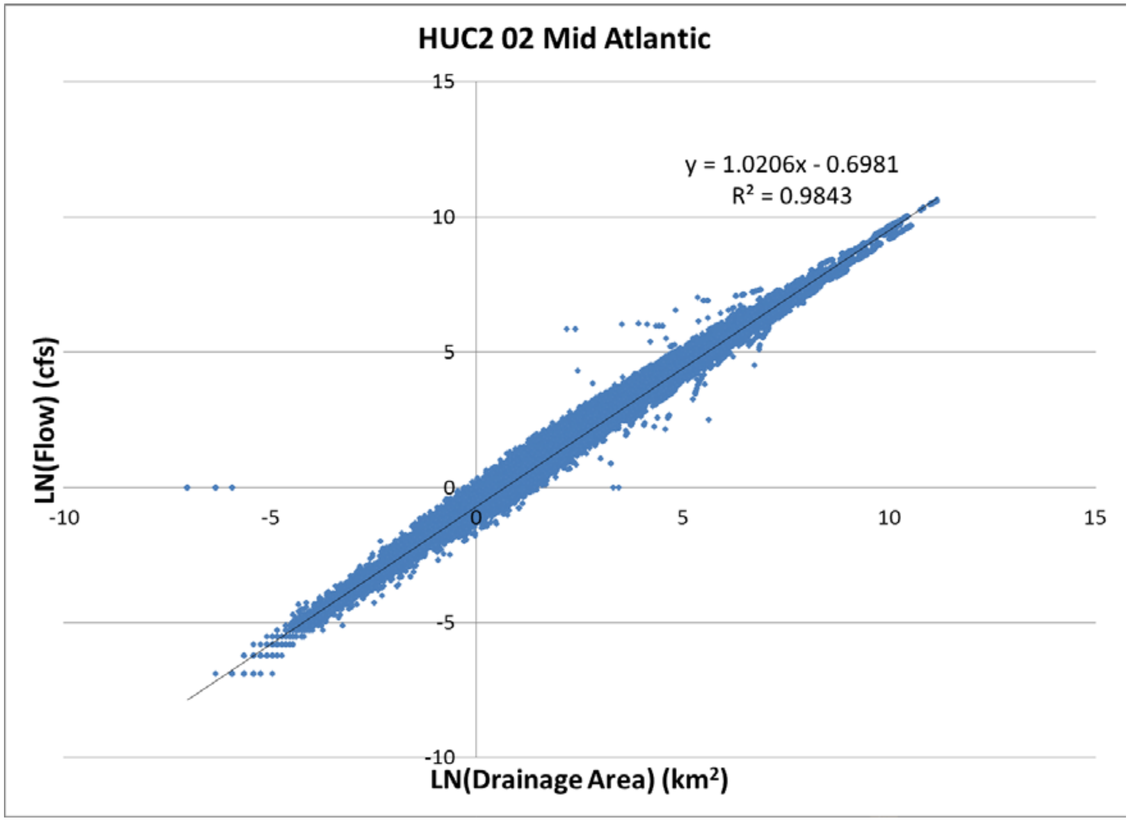
A process was followed to derive the additional required parameters, and evaluate additional required assumptions.

Screening Level Aquatic Exposure Modeling: Flowing Water Habitat Watershed Area and Length

The NHDPlus V2 dataset includes drainage area and mean annual flow rate for every flowing water body segment across the US (lower 48)

Linear regressions on the LN-transformed data and the raw data pairs were developed for each HUC2 to estimate drainage area for target flow rates

- If R^2 value for LN-transformed data > 0.9, LN regression selected, otherwise, better fit of LN and non-transformed data was selected

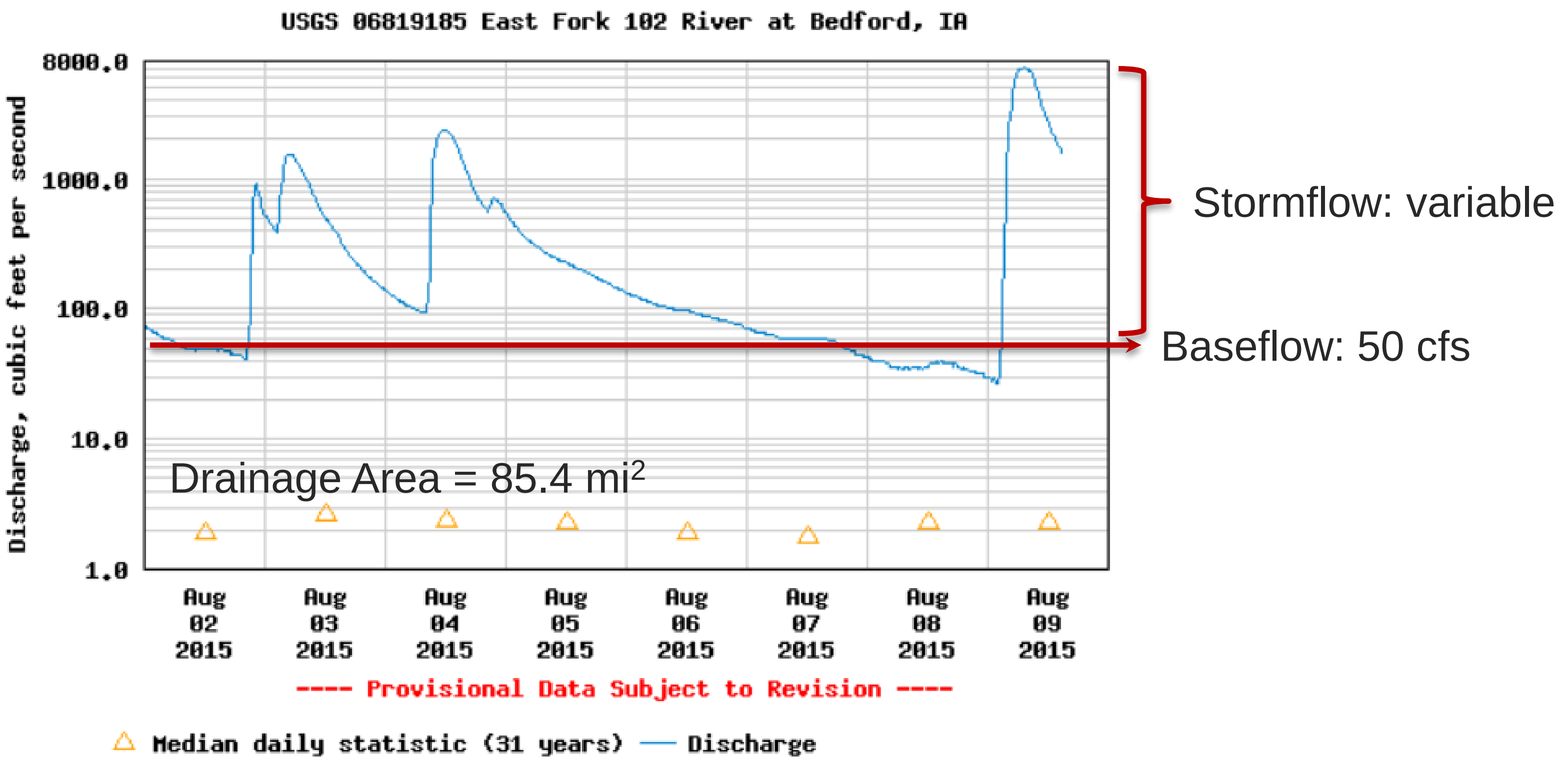


Other Issues:

- Some HUC2s do not have flows as high as 100 m³/s (high flow bin); High flow bin was capped at the maximum "observed" flow

Screening Level Aquatic Exposure Modeling: Volume and Flow Through Rate

Real world flowing water bodies are dynamic; volume, flow rate, flow velocity, and sediment load change



A parameterization of VVWM that recognizes changes in total volume and changes in flow through rate would best represent real world conditions

Screening Level Aquatic Exposure Modeling: Variable Volume or Constant Volume?

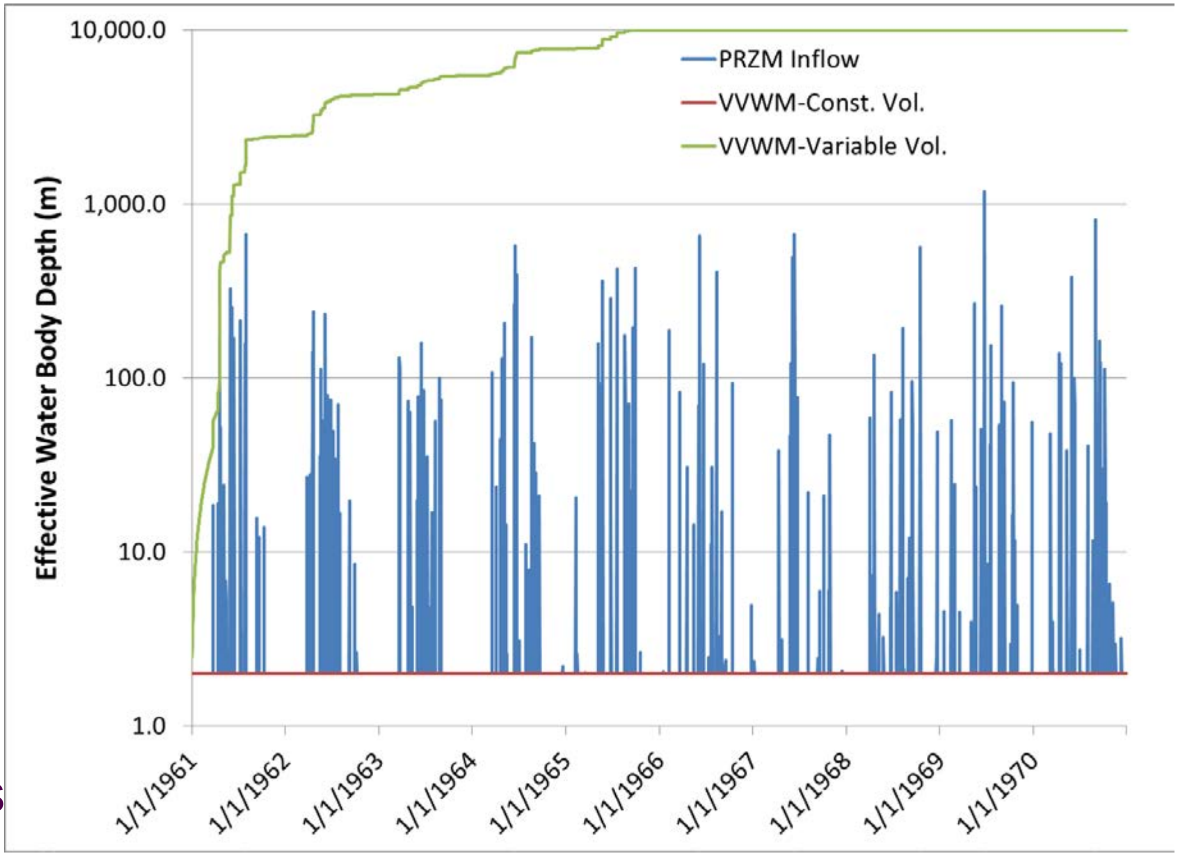
The current version of VVWM does not allow the water body volume to change the way a flowing water system does.

- Constant volume option: volume stays the same, but flow rate through the constant volume can change
- Variable volume option: volume can rise during a runoff event, but does not fall as the runoff event passes

The variable volume option results in steadily increasing water body depth until max is reached

The better option is to set a constant volume for the entire simulation

A variable flow through rate will capture some of the real dynamics



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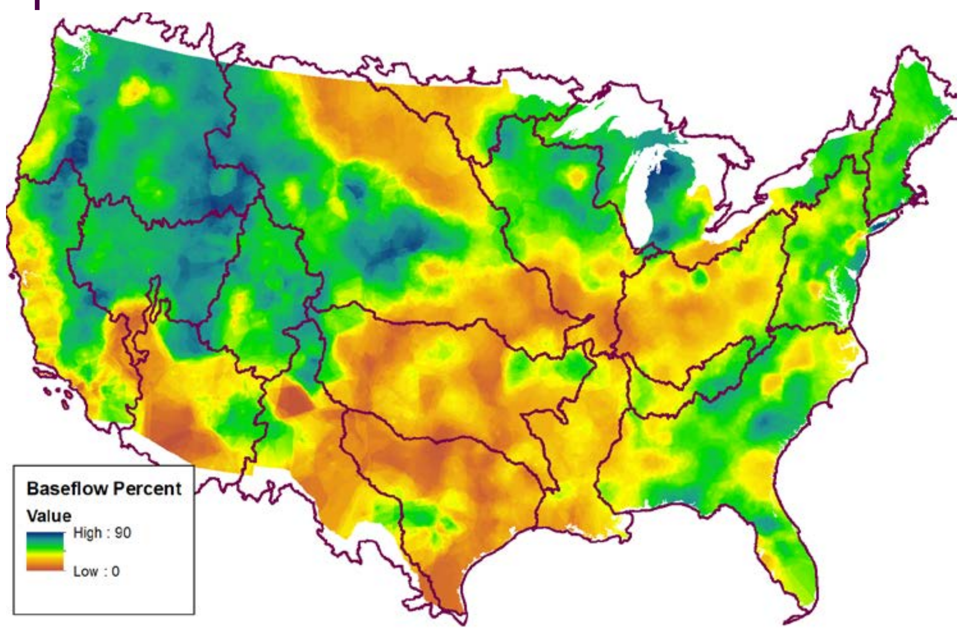
Screening Level Aquatic Exposure Modeling: Constant Flow Rate or Variable Flow Rate?

The generic flowing water habitats defined by US EPA/NMFS are associated with a specific flow rate.

- Constant flow rate option: A constant flow rate equal to the habitat's specified flow rate could be set through a constant baseflow rate in VVWM
- Variable flow rate option: The daily flow through the water body could be allowed to vary between a baseflow rate and baseflow + storm flow rate

The option that best matches the conceptual model of a flowing water system, is variable flow rate based on daily runoff inputs from PRZM.

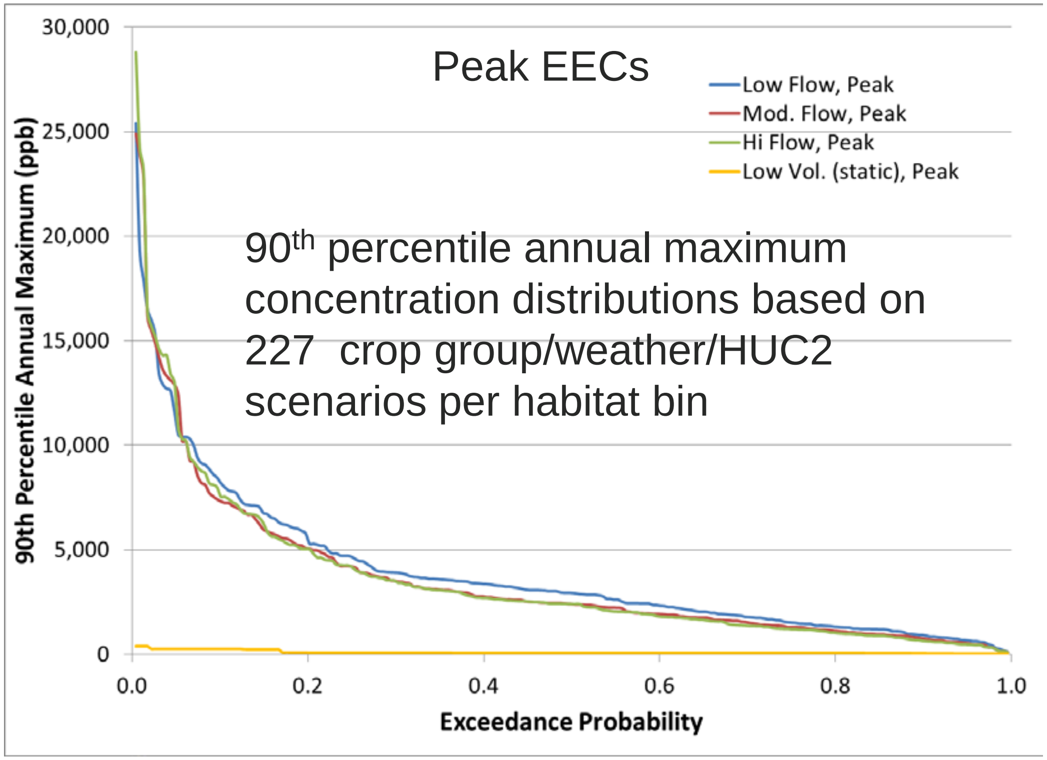
- Baseflow fraction (BF) of mean annual flow determined from national USGS baseflow analysis
- Mean BF for HUC2 multiplied by target flow for habitat to calculate baseflow rate
- PRZM runoff rate determined additional flow for storm days

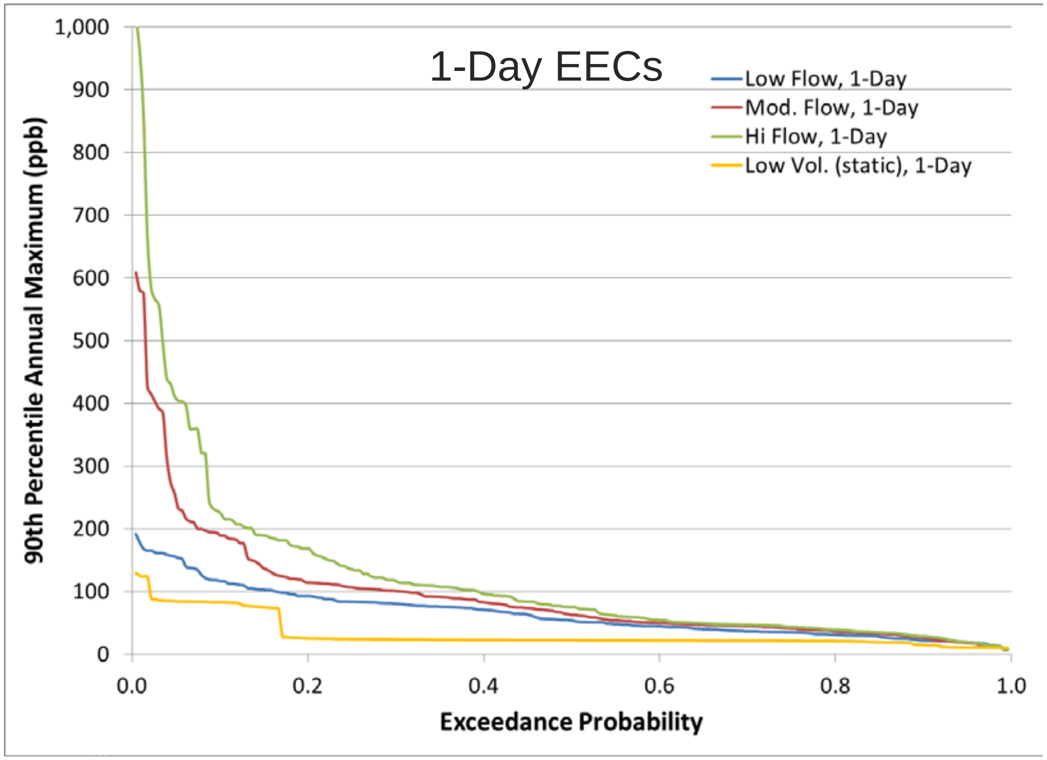


Screening Level Aquatic Exposure Modeling: Initial Results for Flowing Water Bodies

Initial results for flowing water bodies were surprising

- Concentrations remarkably higher than static water bodies
- Peak concentrations orders of magnitude higher than daily average





Flowing water peak concentrations exceed 5,000 ppb in 20% of scenarios

- Maximum daily concentration in field runoff water over 30 years: 43.4 ppb
- Chlorpyrifos solubility: 1,400 ppb

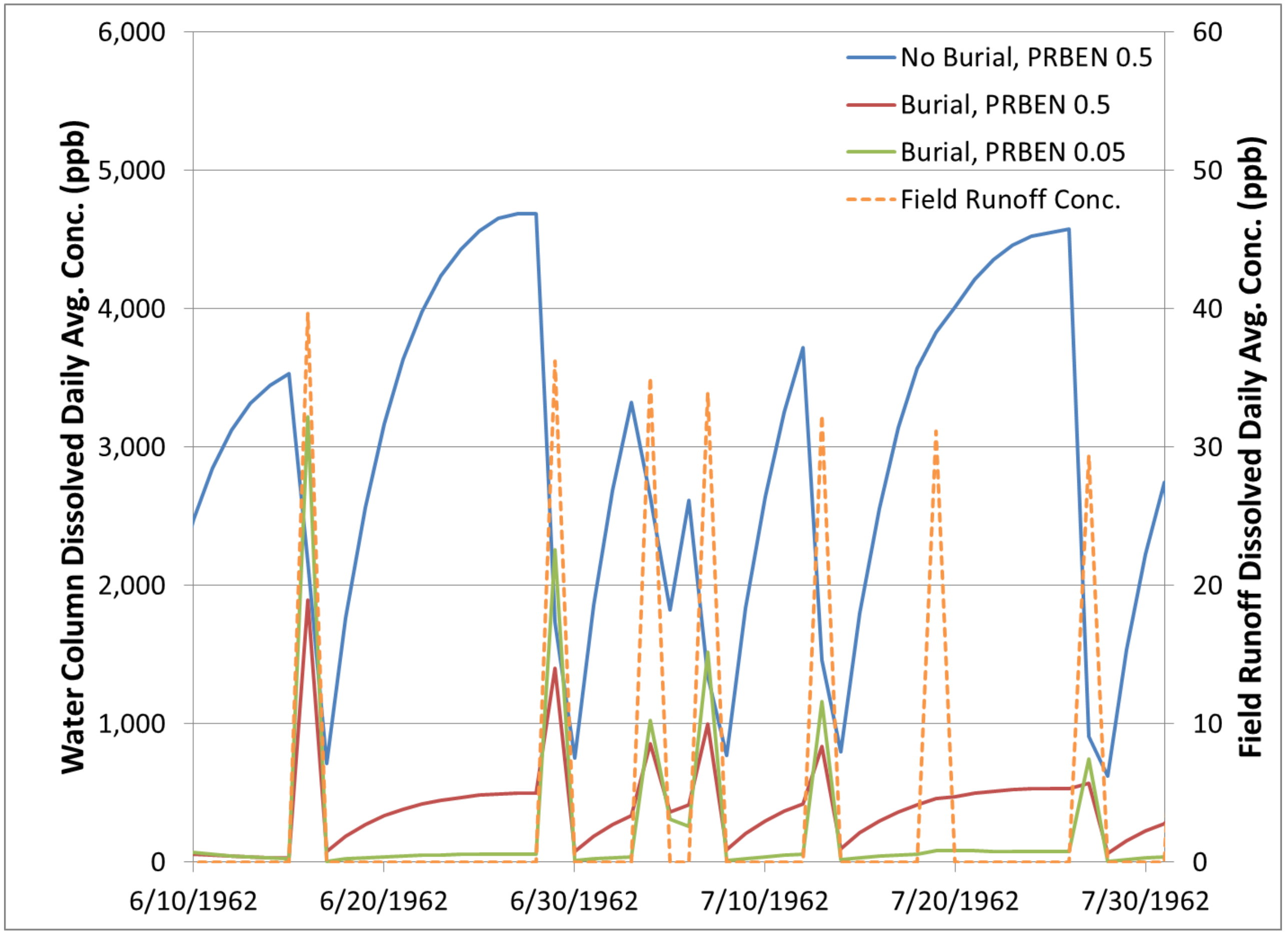
Screening Level Aquatic Exposure Modeling: Effects of Sediment Processes

VVWM offers two processes to account for sorbed pesticide and sediment

- PRBEN: Instantaneous transfer of a portion of sorbed pesticide to the benthic (initially set to default of 0.5)
- Burial: Incoming sediment load "buries" pesticide in active benthic layer (Note: Burial bug in SWCC 1.106 fixed in this example)

Observations:

- With burial "off", highest daily conc. occurs days after runoff event
- Burial "on" results in daily peaks coincident with runoff events
- Lower PRBEN limits significant rise in conc. days after runoff event

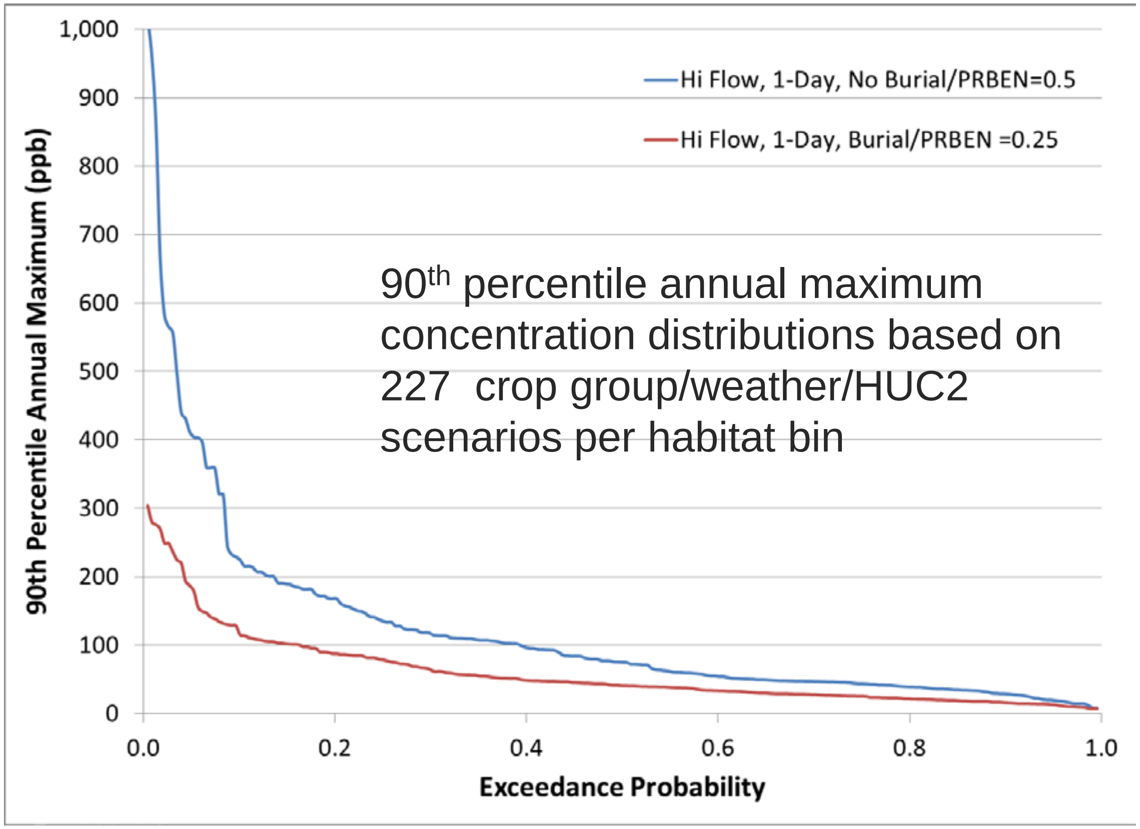


Screening Level Aquatic Exposure Modeling: Most Realistic Flowing Water SWCC Parameterization

Using the current SWCC model, the most realistic parameterization should include:

- Burial enabled to account for sediment deposition in channel bottom
- Potentially PRBEN reduced to account for sorbed pesticide outflow
- Percent Cropped Area (PCA) applied in a way analogous to drinking water assessments

The predicted 90th percentile concentrations in large flowing water bodies are higher than the concentrations predicted in all static water body sizes.



The best parameterization possible with a single SWCC simulation lacks the realism to adequately represent a watershed and flowing water body system.

Screening Level Aquatic Exposure Modeling: Recommendations for Flowing Water Simulations

Peak concentration calculations: The current assumption of instantaneous pesticide loading into a receiving water with no increase in water volume is conceptually impossible and should be corrected.

Sediment Dynamics: The burial and transfer of sorbed pesticide to the benthic layer (PRBEN) inadequately account for actual flowing water processes and should be replaced with algorithms that follow sediment transport principles.

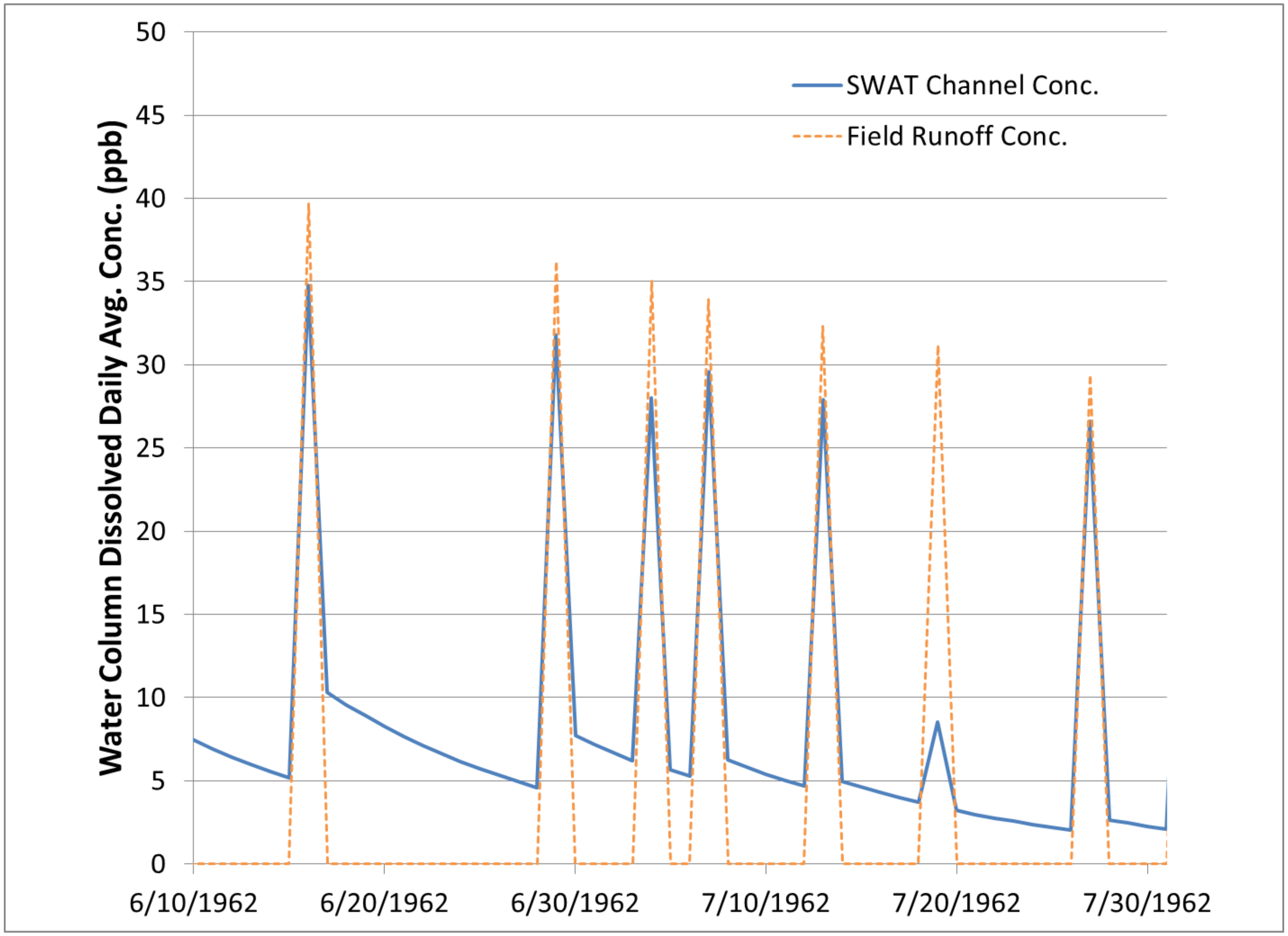
Flowing Water Volume Dynamics: The rising and falling of flowing water body depth during and after storm events should be represented to more accurately reflect the volume of water available for pesticide mass dilution on each day.

Watershed Heterogeneity: Watersheds draining to the flowing water body habitats, are currently assumed to have the same daily weather and agronomic practices (pesticide applications) across the entire watershed. These assumptions should be modified to reflect the heterogeneity that occurs in real world watersheds, especially for medium and large water bodies.

Screening Level Aquatic Exposure Modeling: Alternatives for Flowing System Channel Modeling

The Soil and Water Assessment Tool (SWAT) is a watershed scale water quality model that contains upland and channel components.

Preliminary results from a SWAT parameterization of a large flowing water habitat, taking runoff, sediment, and chlorpyrifos loads from PRZM, align with our conceptual understanding of pesticides in flowing water systems.



Summary

A screening level aquatic exposure assessment was conducted following the approach for aquatic modeling outlined by the US EPA and Services.

Modeling of the static water body habitats followed standard, conservative approaches developed by the US EPA for regulatory modeling of exposure in static, high vulnerability farm ponds.

The simulation of chlorpyrifos EECs in flowing water habitats was conducted using the same modeling tools that have been designed for static water bodies (SWCC), and parameterized according to an approach proposed by US EPA.

The results of the simulations showed significantly higher vulnerability in all sizes of flowing water habitat compared to the static water body habitats, in stark contrast to our conceptual understating of these systems.

Our conclusion is that the currently available regulatory aquatic exposure modeling tools need revisions or replacement in order to adequately model flowing water systems required for national endangered species assessments.

Thank you.

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