Modeling the Benefits of Urban Pesticide Application Best Management Practices in Reducing Pesticide Aquatic Ecosystem Exposure

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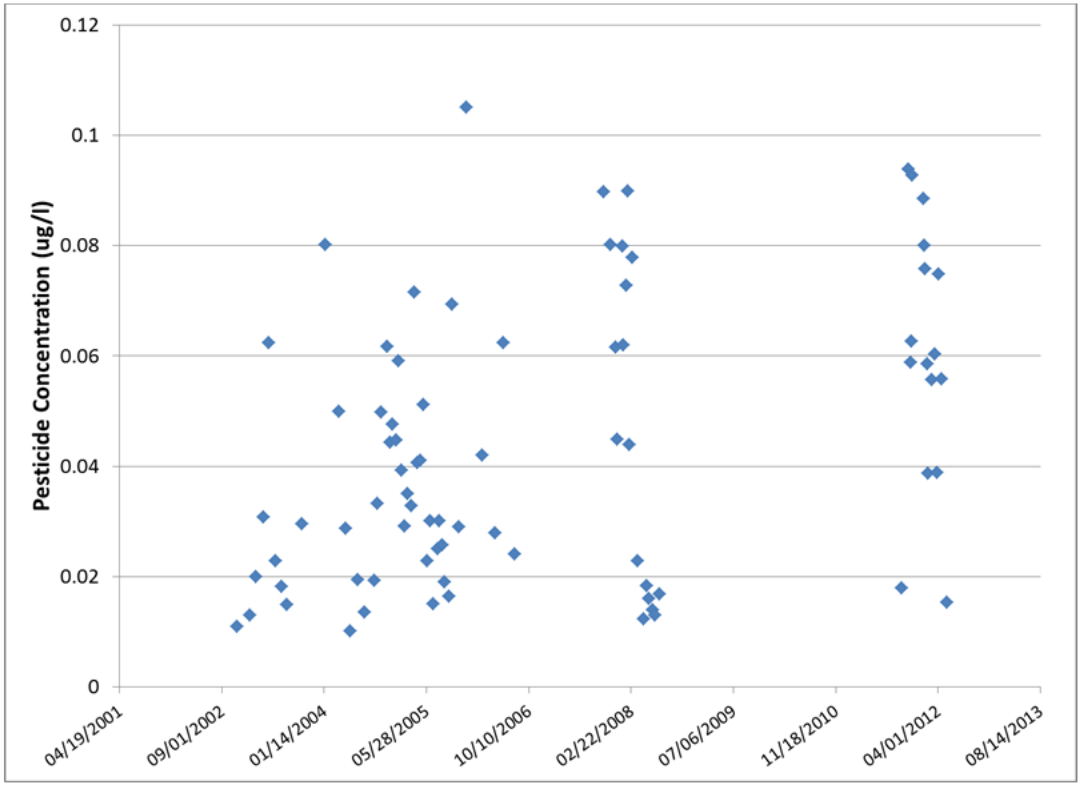
Background: Motivation for Modeling of Urban Pesticide Concentrations

- Use of pesticides in urban environments has resulted in detections of these pesticides in some urban drainage systems.

- These urban pesticide detections have led to a need for evaluation of urban ecological exposure potential.

- Supported by monitoring datasets, simulation modeling can estimate pesticide concentrations in urban receiving waters.



Arcade Creek, Del Paso Heights, CA

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Background: Modeling Approach Requirements

- The urban pesticide modeling approach must:
  - Capture the heterogeneity in use sites found in an urban environment.
  - Account for the hydrologic processes in residential watersheds.
  - Allows the flexibility in use assumptions
  - Permit evaluation of mitigation effectiveness
- Model must be validated with monitoring data.

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Plot Scale BMP Effectiveness: PWG Pathway ID Study

- Determine the important pathways for off-site movement from residential applications (essential to developing effective mitigation practices).
- Determine the effectiveness of spot (crack and crevice) treatments for reducing residues from applications to driveways and adjacent surfaces (Davidson et al., 2014).

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Plot Scale BMP Effectiveness: Applications To Garage Wall

Historic Practices: blue and pink
Revised Practices: pink only

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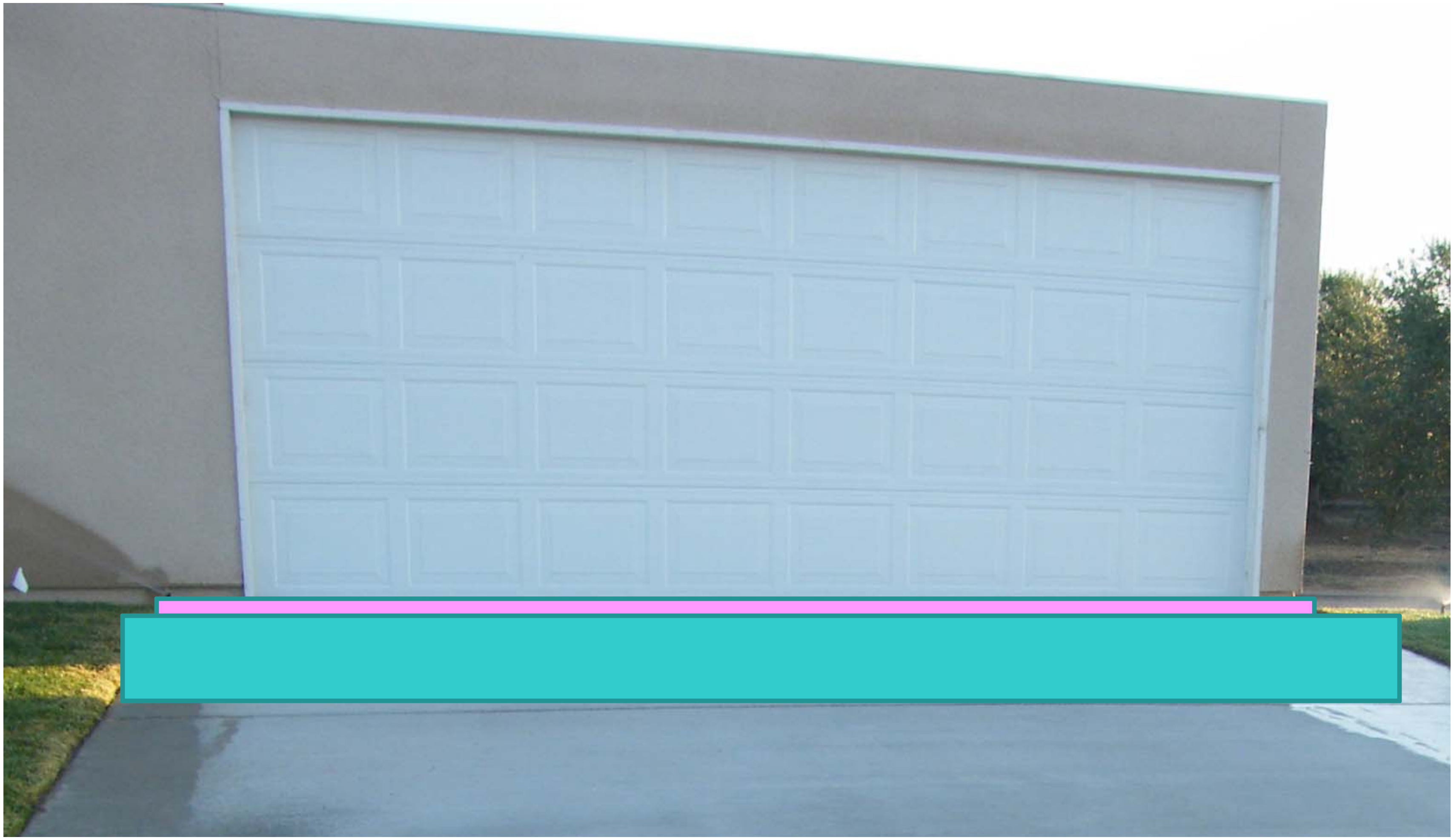
Plot Scale BMP Effectiveness: Applications To Driveway



Historic Practices: blue and pink
Revised Practices: pink only

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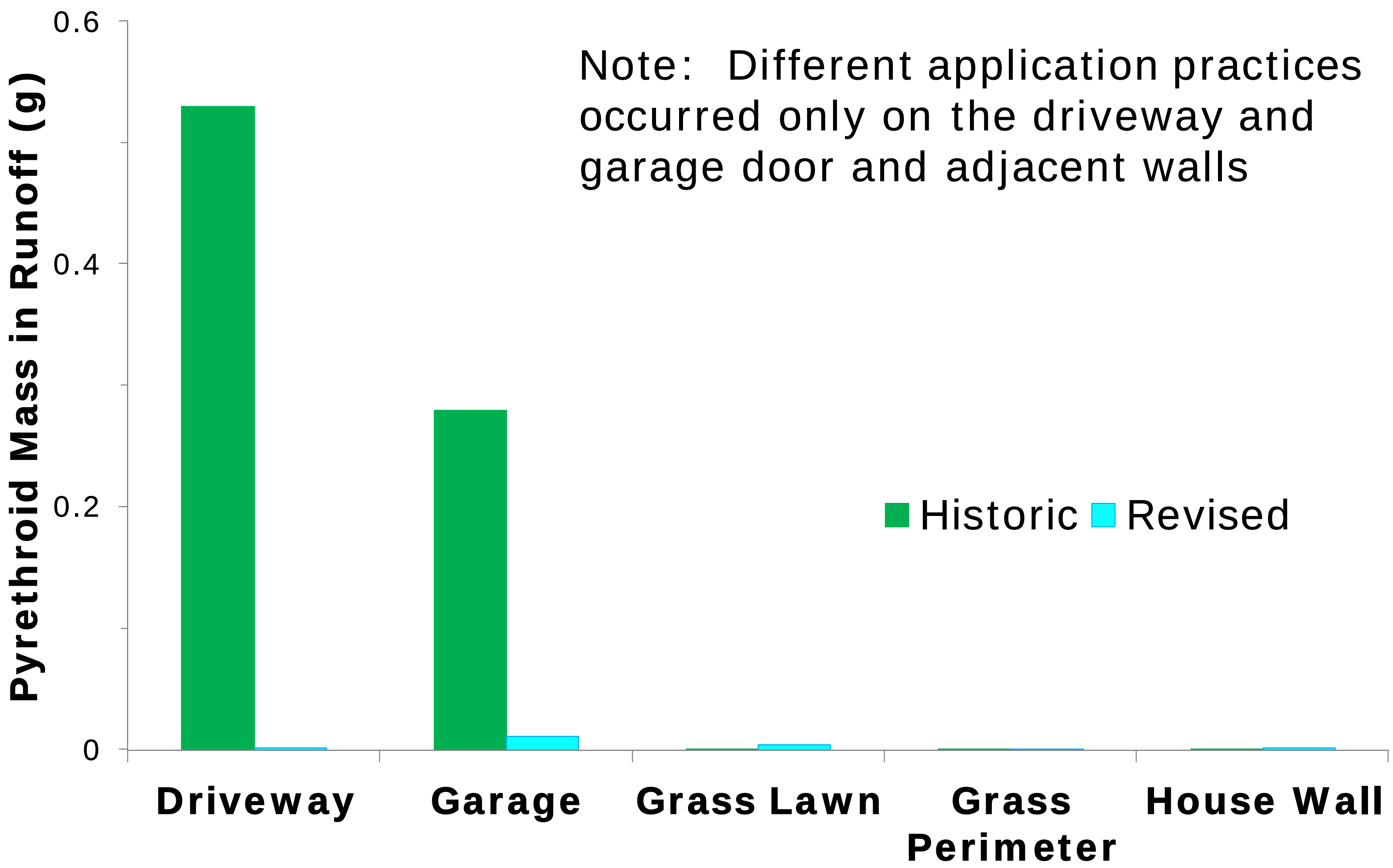
Plot Scale BMP Effectiveness: Reduction in Observed Mass Loss



- These data can be used in parameterizing a watershed model.

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Modeling Approach: SWMM-AGRO Model Selection

- Storm Water Management Model (SWMM): US EPA
  - Watershed scale, urban/residential water quantity and quality model
  - Strength in handling of sub-hourly runoff and flow routing
  - Able to model multiple surface types (lawn, driveway, etc.)

- AGRO: Canadian Center for Environmental Modeling (CEMC)
  - Water Quality Model: Quantitative Water, Air, Sediment Interaction (QWASI) Fugacity model (Mackay, 2001).
  - Accounts for chemical mass exchange between water column (dissolved and sorbed compartments), benthic layer (dissolved and sorbed compartments), and air.
  - Simulation of sediment dynamics, including handling of incoming sediment; important for high Koc pyrethroids.
  - AGRO-2014 (Padilla and Winchell, 2013) includes improvement in parameterization based on comparison with cosm study data.

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Modeling Approach: Study Location

- Aliso Viejo, Orange County, CA
- Part of CA DPR / UC Riverside monitoring program (Oki and Haver, 2011).
- Drainage area: 67.2 acres
- 307 homes
- Dwelling unit density: 4.6 units/acre.

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Modeling Approach: Conceptual Model

- Aliso Viejo neighborhood was spatially delineated.
- Particular attention to impervious use sites.
  - Lower driveway
  - Upper driveway (within 5 ft)
  - Garage door
  - Impervious within 5-ft foundation perimeter
  - Patios/walkways away from building
- Impervious areas near lawns (1.5 ft) receive irrigation.
- A fraction of impervious surfaces (other than driveway) flow into adjacent lawns.

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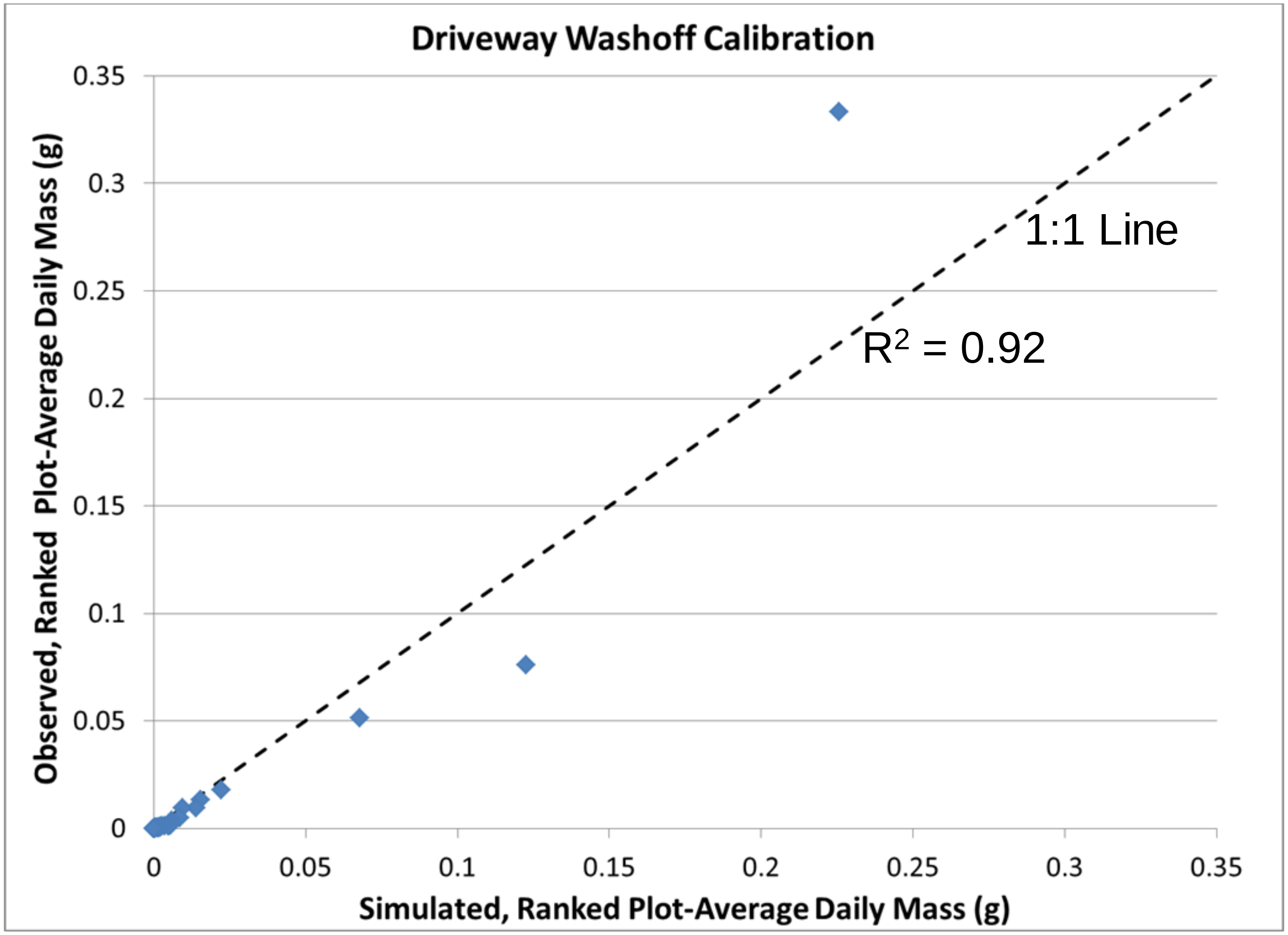
Modeling Approach: Pesticide Wash-Off Calibration

- A SWMM model was developed to simulate washoff (historical practices) from the Pathway ID study (driveway and the lawn).
- Calibrations sought to match observed total washoff and daily washoff distribution.
- The Pathway ID washoff calibration served as the basis for the neighborhood model scenario.



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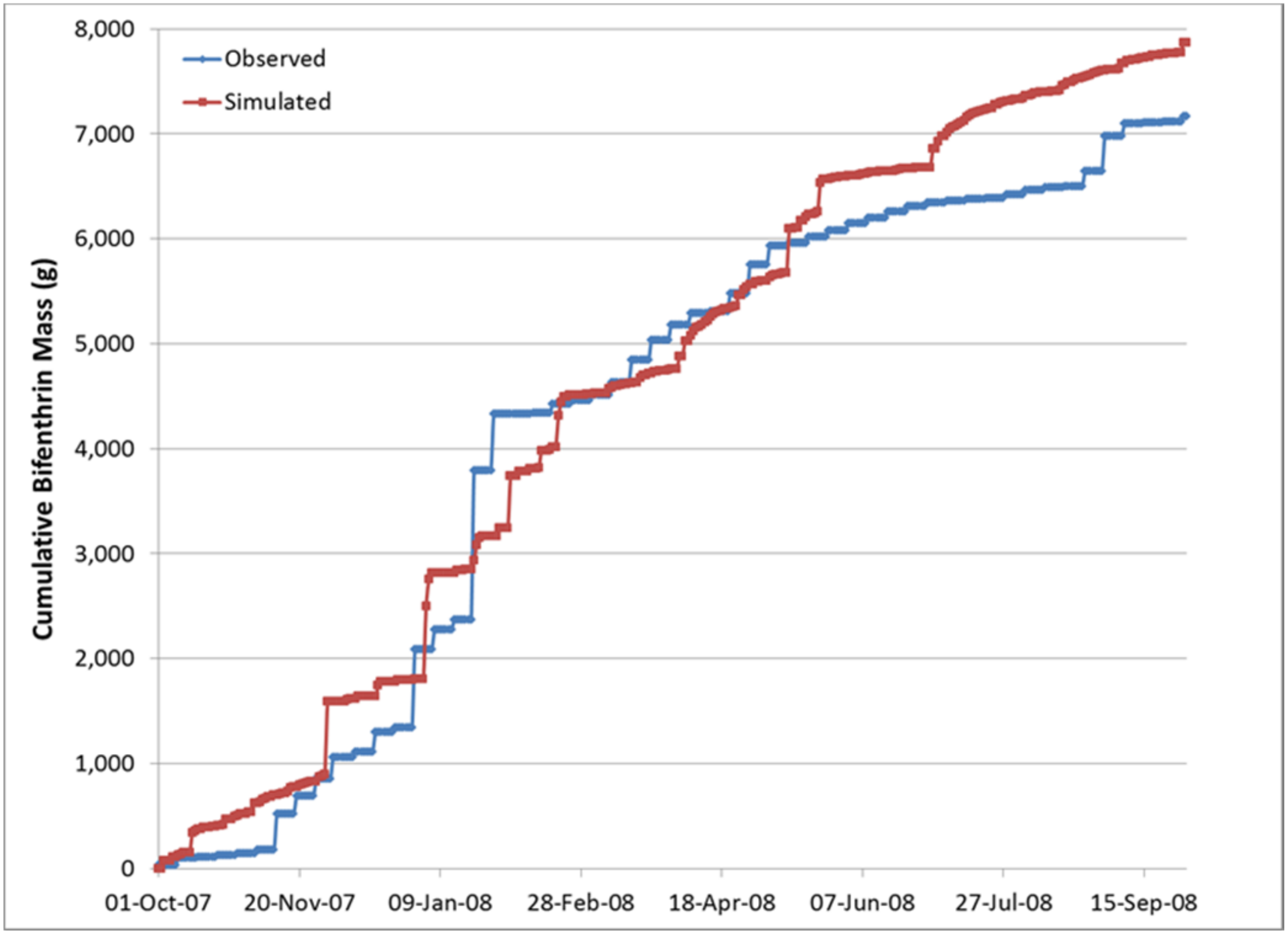
Modeling Approach: Watershed Scale Pesticide Simulation

- The simulated cumulative bifenthrin mass load over 1 year was compared to the observed mass load.

- Over the 1 year period, the model predicted close to the observed load.

- The validated modeling approach could now be used to assess BMPs.



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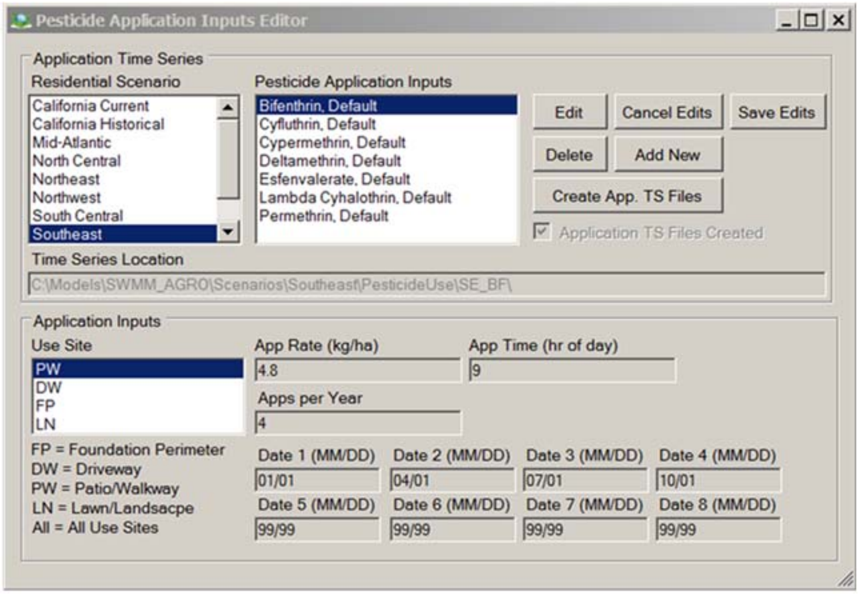
Model Application: Evaluating BMPs and Labeling Alternatives

- Using the validated SWMM-AGRO model residential scenario, the effects on ecological exposure of a range of BMPs and label alternatives can be evaluated:
  - Modifying the treated width in perimeter applications
  - Modifying the number of applications per season
  - Reducing over-irrigation
  - Splitting applications to occur at lower rates at a higher frequency
  - AI-specific mitigations
- These simulations can be efficiently evaluated with the SWMM-AGRO model interface.



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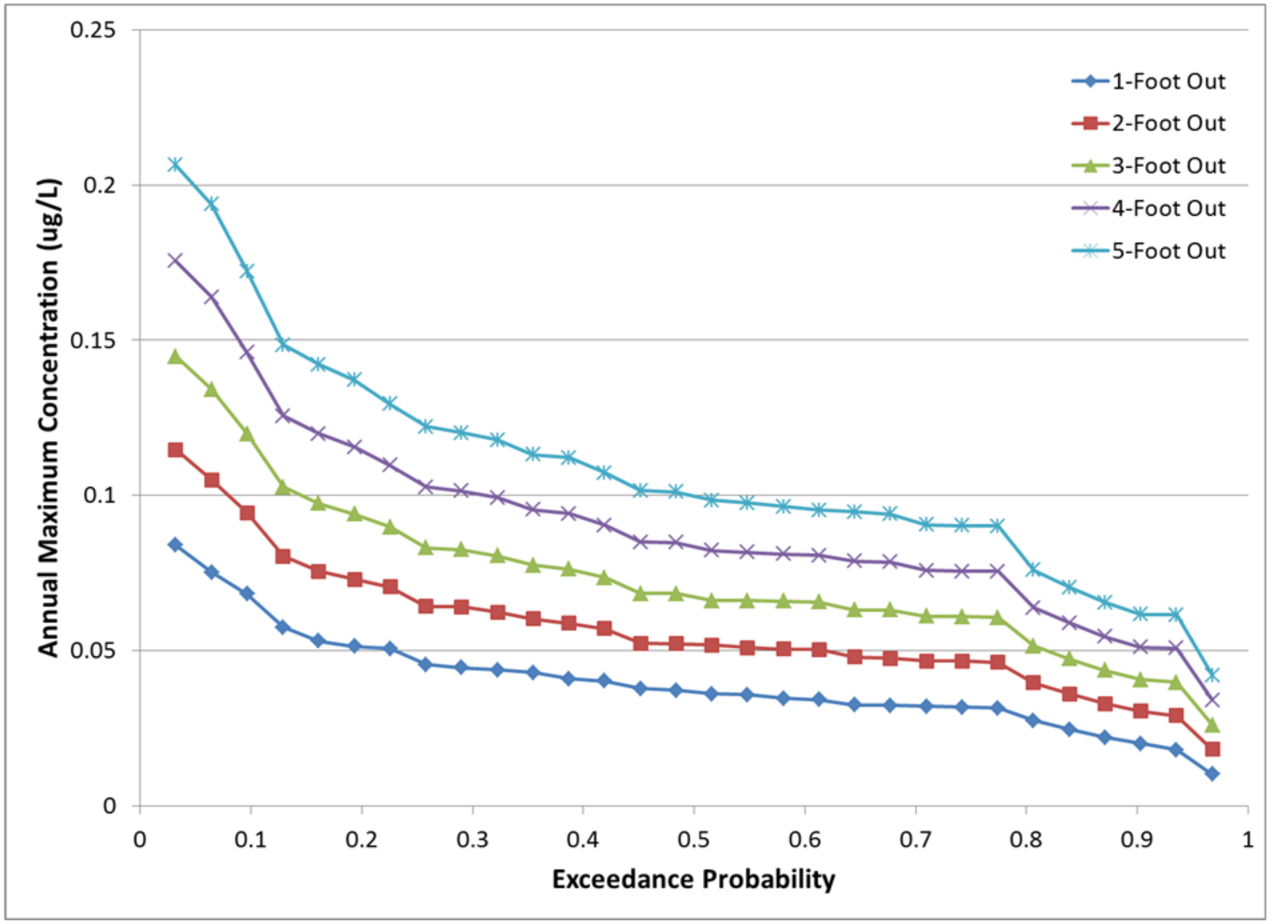
Model Application: Evaluation of Mitigation by Reducing Treated Width

- The foundation perimeter treatment was varied in 1 ft. increments from a standard 5 ft. out down to 1 ft. out.
- The effects of annual maximum EECs in a receiving water are shown.
- Reductions in max EECs with decreasing width treated are nearly linear.
- Lowering the treated width may be an effective mitigation strategy.



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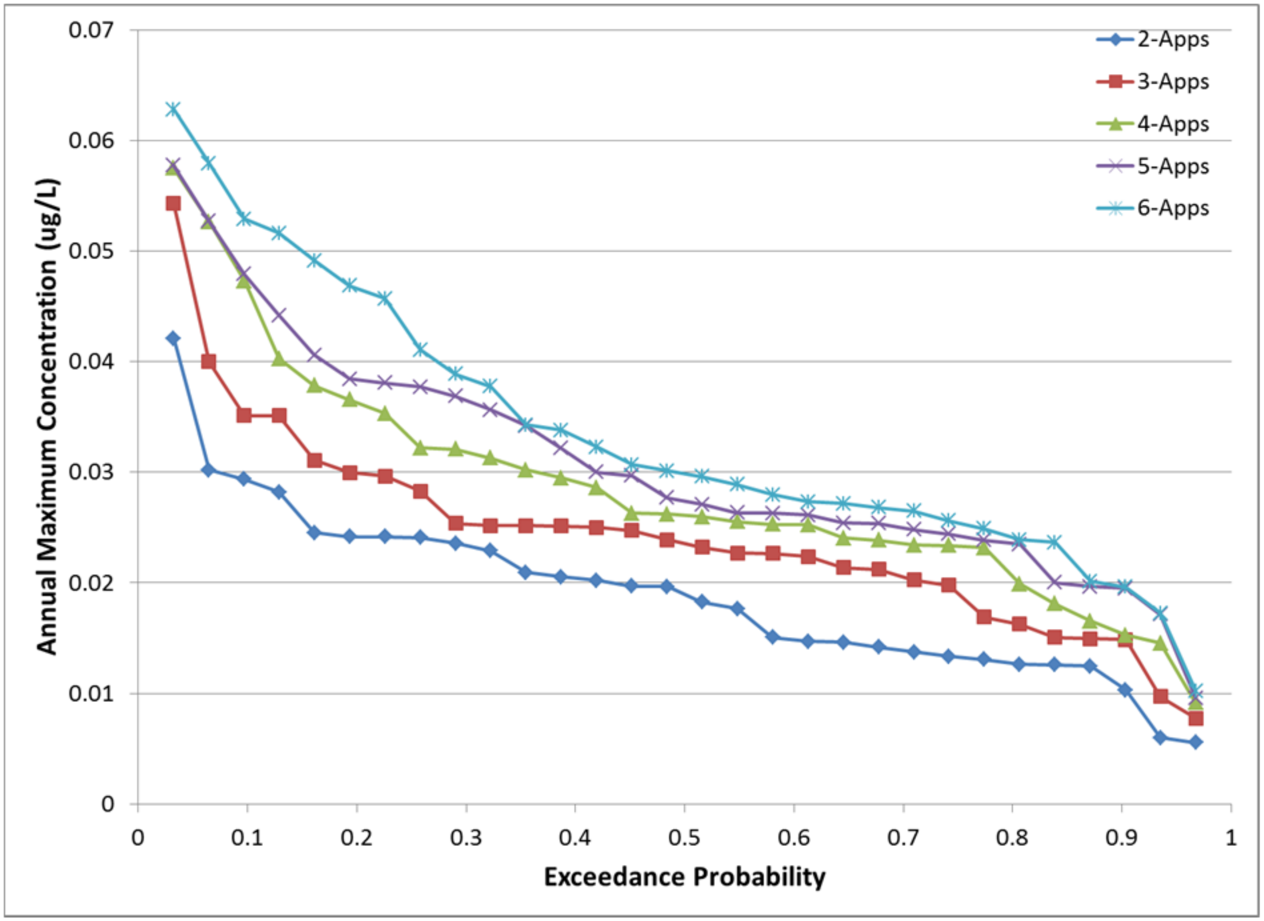
Model Application: Evaluation of Mitigation by Reducing Applications

- The number of applications made to all residential use sites was varied between 2 and 6 applications per year.
- The single application rate was kept constant.
- The change in annual max EECs is not linear as a function of apps.
- A reduction in the number of apps from 6 to 2 results in less than a 50% reduction in the 90th percentile EEC.



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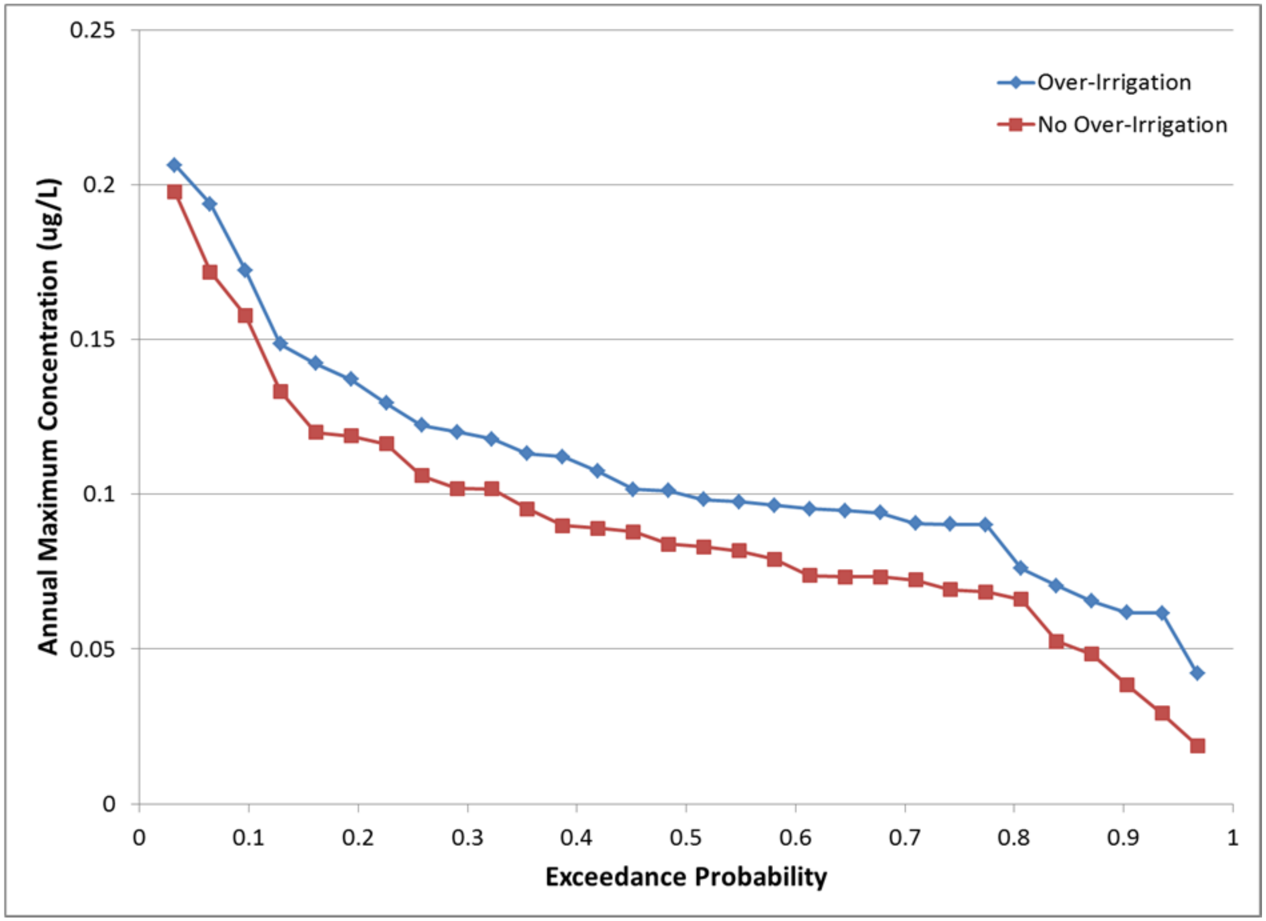
Model Application: Evaluation of Mitigation by Reducing Over-Irrigation

- The residential modeling scenario developed included over-irrigation onto impervious surfaces adjacent to lawns.
- Observed flow and concentration showed this to be common.
- A modification of the scenario to completely remove off-target over-irrigation was made.
- A less than 9% reduction in 90th percentile EECs was predicted from this mitigation strategy.



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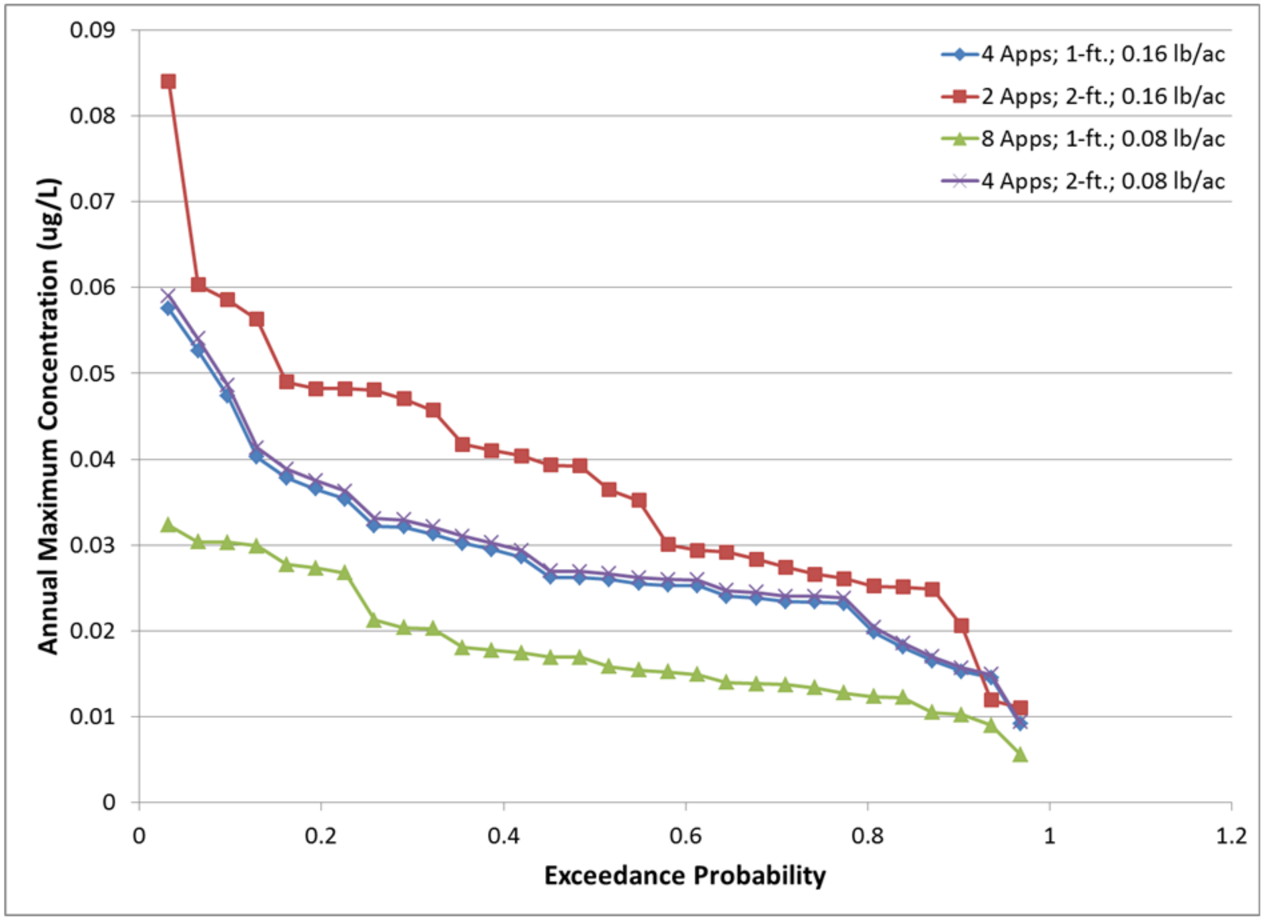
Model Application: Evaluation of Rate, Number of Apps, and Treated Width

- Complex alternatives that vary application rate, number of applications, and treated width can be assessed.
- All 4 alternatives results in the same total pounds applied.
- The lower frequency, higher rate option was found to result in the highest EECs.
- The more frequent lower rate, lower treated area option resulted in the lowest EECs and represents the best mitigation option.



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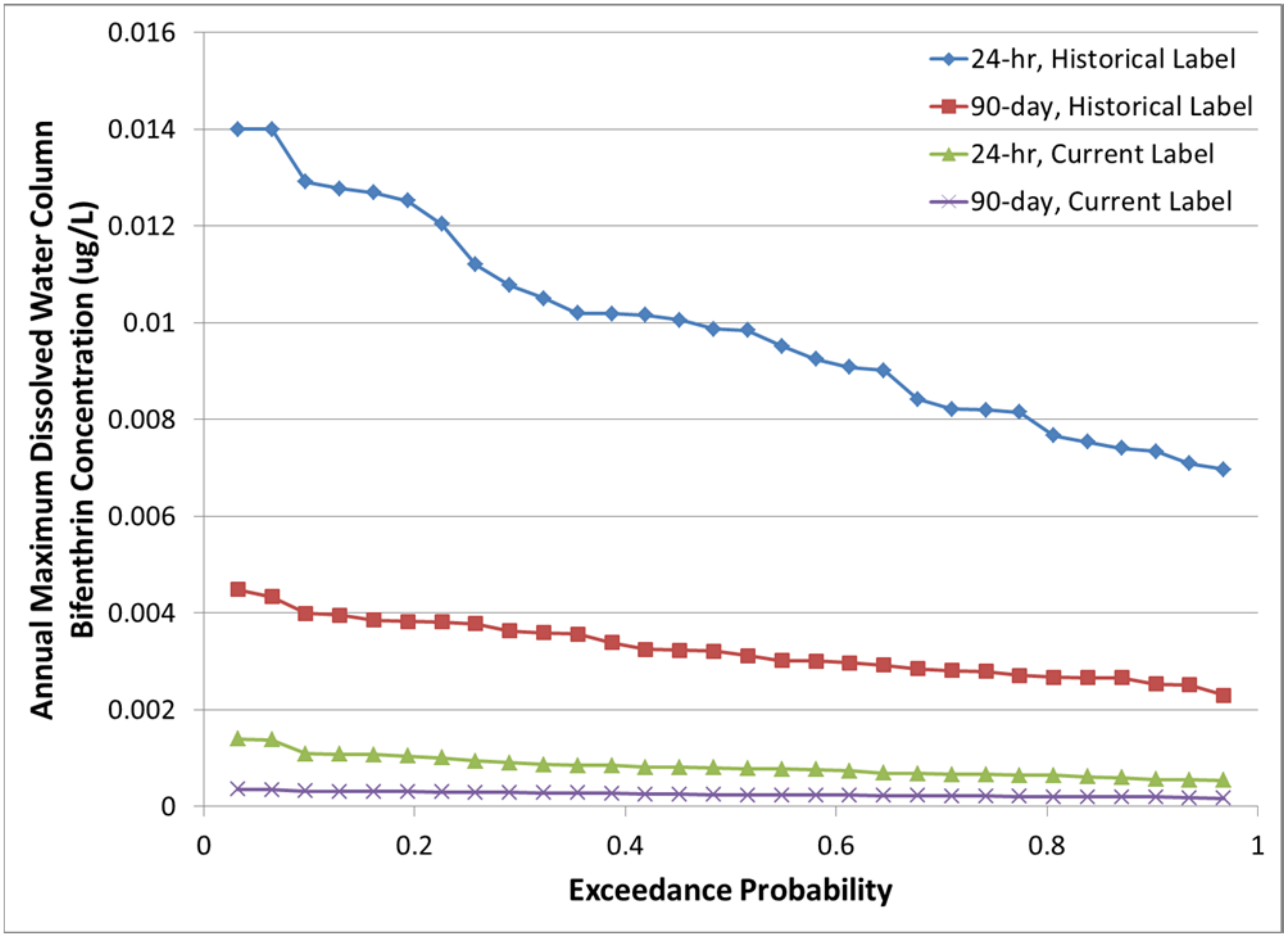
Model Application: Pyrethroids, California Historical vs. Current Best Practices

- Current pyrethroid labels (as of ~2010) limit applications on hard surfaces to crack and crevice applications.
- Bifenthrin EEC distributions show a reduction in annual maximum EECs of ~10x after incorporating new label restrictions into the residential scenario.
- In this example, BMP effectiveness accounts for use site area application reduction only.



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Summary and Conclusions

- An approach for modeling pesticide exposure in urban water bodies was developed for use in ecological risk assessments and in the evaluation of BMPs and exposure mitigation strategies.

- The watershed scale modeling approach was developed using field data from plot scale pesticide washoff simulations and stormwater monitoring data in California.

- The validated model has been used in evaluating new pyrethroid label requirements and has been tested in the assessment of alternative mitigation strategies.

- The SWMM-AGRO platform will allow efficient analysis of urban pesticide runoff mitigation strategies aimed at improving environmental stewardship.

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Acknowledgements and References

- Acknowledgements:
  - Funding provided by the Pyrethroid Working Group

- References:

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