Urban runoff as a source of pyrethroid pesticides and resulting water column toxicity

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Pyrethroid sources

- Agricultural return flow

  About 10% of our ag samples contain pyrethroids

- Municipal wastewater treatment plants

  About half of our treatment plant samples contain pyrethroids

- Urban runoff

  Virtually all our urban runoff samples contain pyrethroids

Toxicity testing species: Hyalella azteca

Used nationally for sediment toxicity testing for many years

A few labs are using it for toxicity testing of water

Our test = 96 hr exposure
Measure mortality and paralysis

Comparative pyrethroid sensitivity of Hyalella to selected other species (based on bifenthrin LC_{50}s)

Amphipod Eohaustorius estuarius = Comparably sensitive
Copepod Eurytemora affinis = Comparably sensitive
Fathead minnow = 5 times less sensitive
Ceriodaphnia dubia = 6 times less sensitive
Rainbow trout = 13 times less sensitive
Delta smelt = 19 times less sensitive

Some basic toxicity information

LC_{50} = concentration that kills half of the test organisms
For several pyrethroids, this is about 3 ng/L (parts per trillion)

EC_{50} = concentration that paralyzes half of the test organisms
For several pyrethroids, this is about 2 ng/L (parts per trillion)

Analytical detection limit of 1 ng/L
(About the threshold of acute toxicity)

$$\text{Toxic Unit (TU)} = \frac{\text{Actual conc.}}{\text{Published } \underline{\text{Hyalella}}\ EC_{50} \text{ conc.}}$$

What 1 ng/L means

Considering only the professional use of pyrethroids in Sacramento County for landscape maintenance and structural pest control (17,416 lb in 2008; excluding retail sales)

Given the land area of Sacramento County (2570 km^2)

How deeply would we have to flood the entire county to reach a concentration in which Hyalella could live (1 ng/L)?

10, 085 feet!

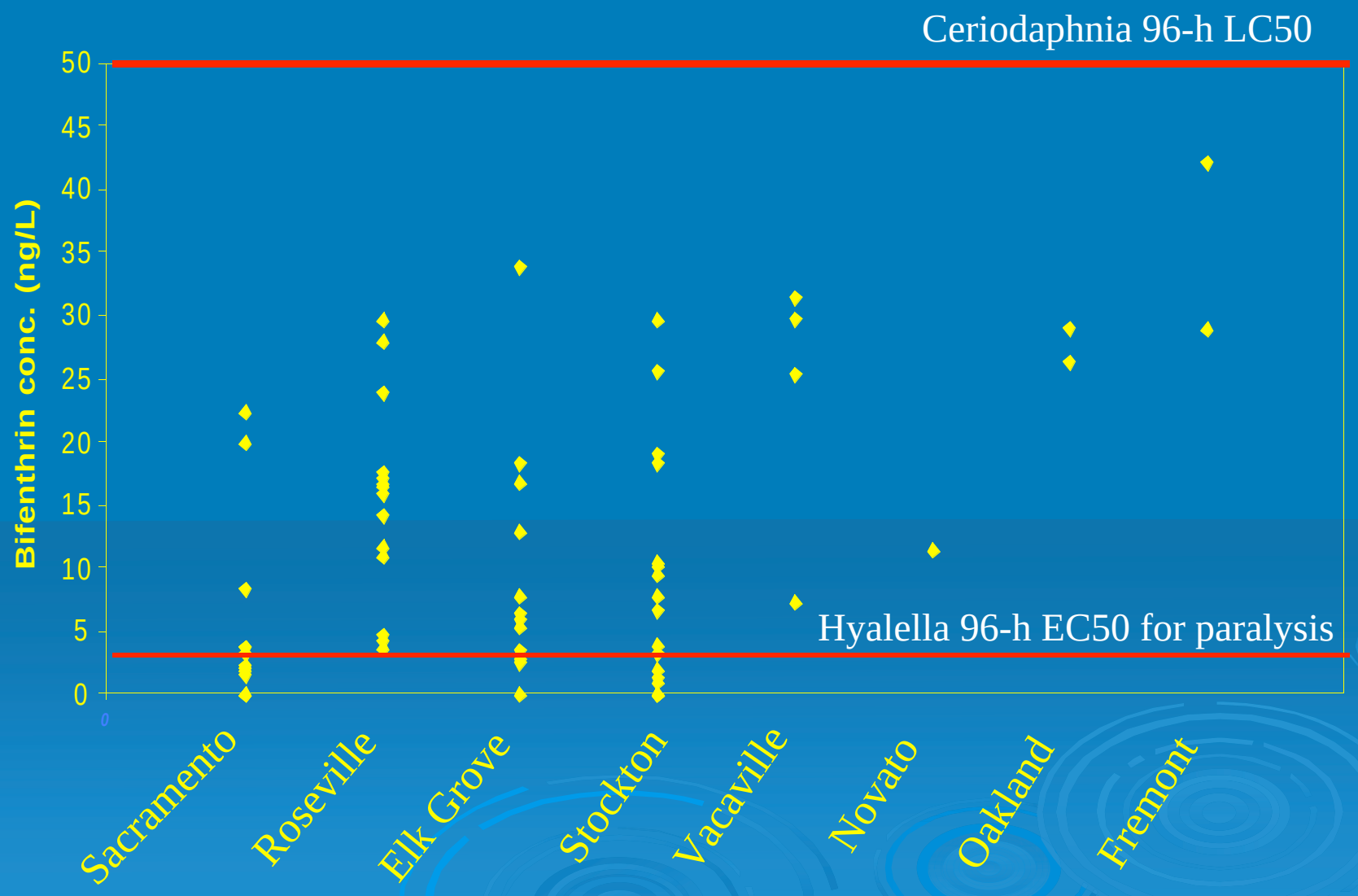
Bifenthrin discharge to urban creeks

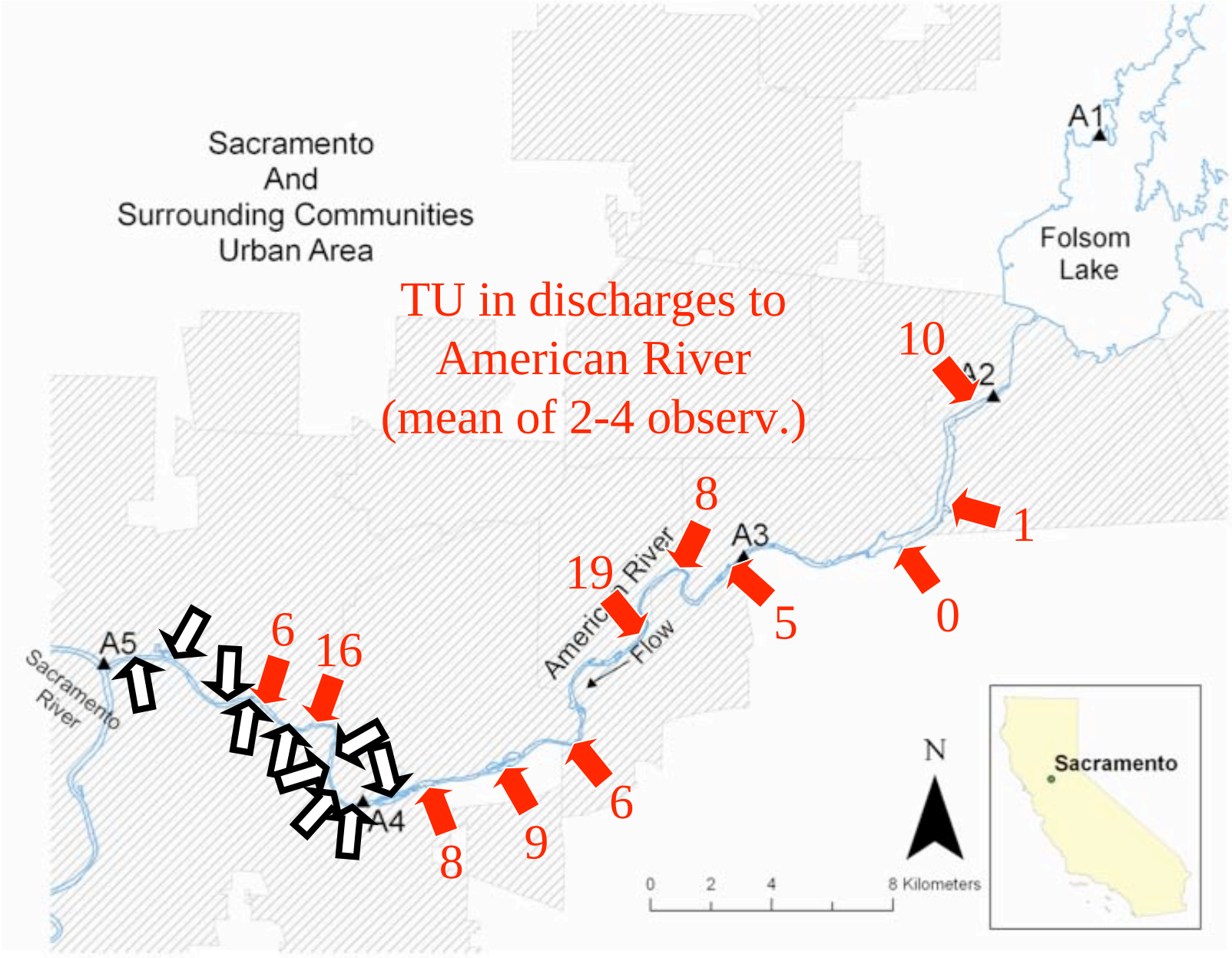
Roseville, CA drains serving 400 homes released 120 mg of bifenthrin over 24 hours in an average storm.

120 mg is enough to contaminate over 11 tons of creek sediment to the Hyalella LC_{50}.

The same 120 mg is enough to contaminate nearly 10 million gallons of water to the Hyalella EC_{50}.

Bifenthrin in urban runoff




Sacramento
And
Surrounding Communities
Urban Area
TU in discharges to
American River
(mean of 2-4 observ.)
A1
Folsom
Lake
10
A2
1
0
8
A3
5
19
American River
Flow
6
16
A5
Sacramento
River
A4
8
9
6
N
0
2
4
8 Kilometers
Sacramento

Back-of-the-envelope calculations suggest a potential problem

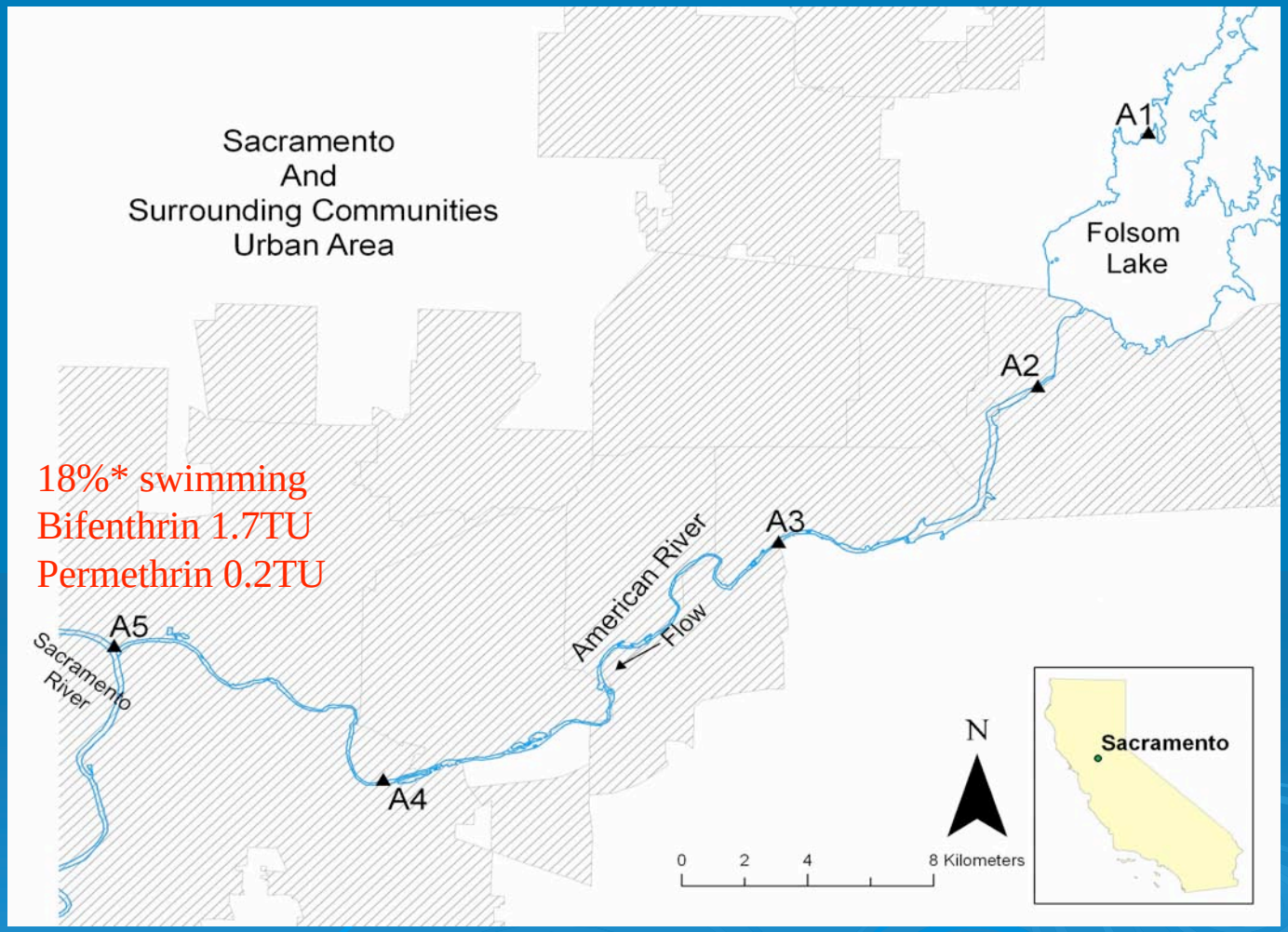
Using January 20, 2010 as an example (0.9 inches precipitation):

Base flow of river (release from Folsom Dam) = 1460 cfs.

We quantified urban runoff from all major inputs
(12 pump stations, 7 creeks, 2 open drains) = 1100 cfs.
Lower reach of river would contain about 40% urban runoff.

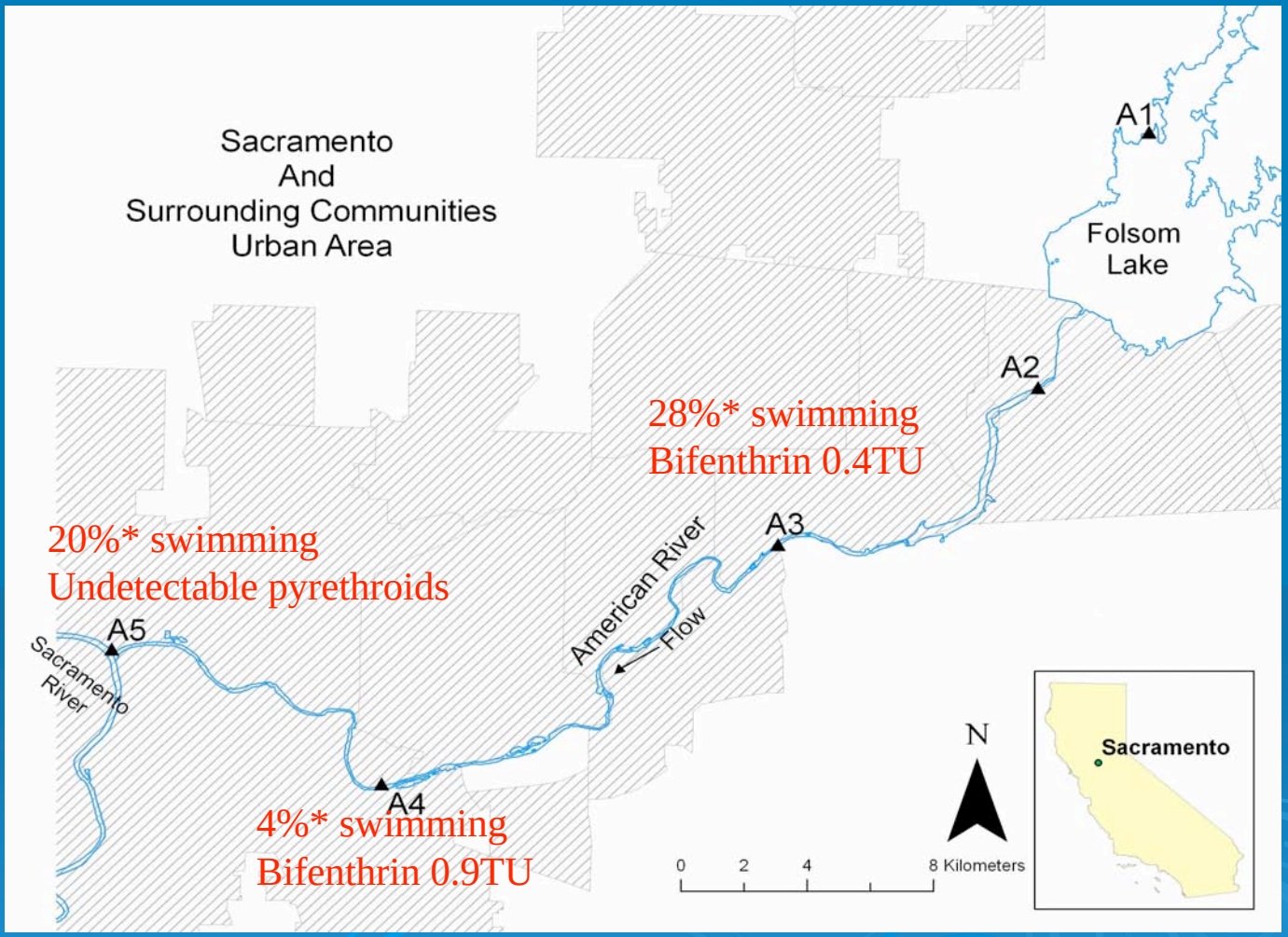
That urban runoff contained on average 9 TU bifenthrin.
If no loss of pyrethroids, river would contain 4 TU.

Feb. 18, 2009 rain event
River sampled only at Discovery Park



18%* swimming
Bifenthrin 1.7TU
Permethrin 0.2TU

Feb. 23, 2009 rain event



3/3/09 770 cfs
nd
nd
nd
2.3 ng/L
2/18/09 780 cfs
5.6
2/23/09 810 cfs
nd
3.1
1.2
1/20/10 1625 cfs
2.1
3.8
nd
nd
1/18/10 1630 cfs
nd
2.2
nd
1/19/10 1635 cfs
1.8
1.5
nd
nd
1/22/10 1650 cfs
nd
nd
nd
nd
10/13/09 2300 cfs
nd
nd
nd
nd
10/13/09 2300 cfs
nd
1.5
nd
nd
5/3/09 4400 cfs
nd
nd
nd
nd

Identifying cause of toxicity
(showing % survival of Hyalella)

River sample	Original sample	PBO addition	Enzyme addition
2/18/09	16	0	no data
2/23/09	4	0	no data
2/23/09	6	0	82
1/18/10	48	4	78
1/19/10	82	8	no data
1/20/10	84	2	no data
1/22/10	80	4	no data

Conclusions

1. Nearly all urban runoff is acutely toxic to sensitive invertebrates.

2. In nearly all cases, toxicity due to bifenthrin (with occasional contributions from cyfluthrin, cypermethrin, cyhalothrin, and permethrin).

3. Bifenthrin capable of regularly causing water column toxicity in the lower American River.

4. Spatial extent and magnitude of toxicity is a function of water management decisions (i.e., dam releases) and their consequences related to contaminant dilution.