On-farm management practices for mitigating toxicity in irrigation run-off

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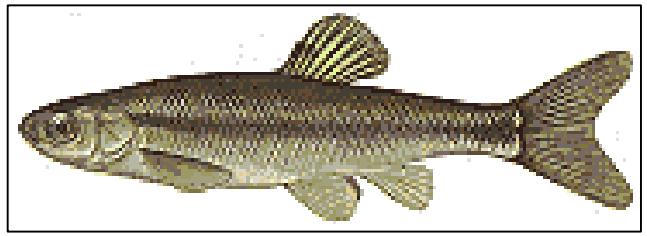
Aquatic Toxicity

Aquatic toxicity is the aggregate toxic effect of a sample measured directly by an aquatic toxicity test.

Aquatic toxicity tests measure biological effects (e.g., survival, growth, reproduction, development).

Acute versus Chronic.



fathead minnow

water flea

amphipod crustacean

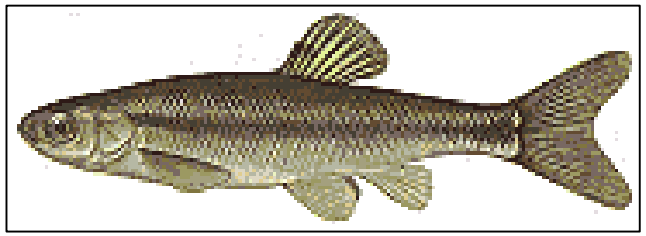
midge fly larva

Solubility & Persistence of Representative Insecticides

Chemical	Log K_{ow}	K_{oc} (mL/g)	Soil Half Life (aerobic)	Water Half Life (photolysis)	Water Half Life (hydrolysis)
DDT	6.0	2,000,000	2 – 15 Years	Weeks – Years	Weeks – Years
Chlorpyrifos	4.7	6,070	7 – 120 Days	21 – 28 Days	35 – 78 Days
Bifenthrin	6.0	240,000	3 – 8 Months	9 – 14 Months	Months – Years
Imidacloprid	0.6	132 - 400	104 – 228 Days	<3 Hours	33 – 44 Days

Insecticide History

Changing Use of Insecticides							
1950	1960	1970	1980	1990	2000	2010	2020
Organochlorines (e.g., DDT)							
		Organophosphates (e.g., Chlorpyrifos)					
			Pyrethroids (e.g., Bifenthrin)				
				Phenylpyrazoles (e.g., Fipronil)			
					Neonicotinoids (Imidacloprid)		



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Comparative Toxicity

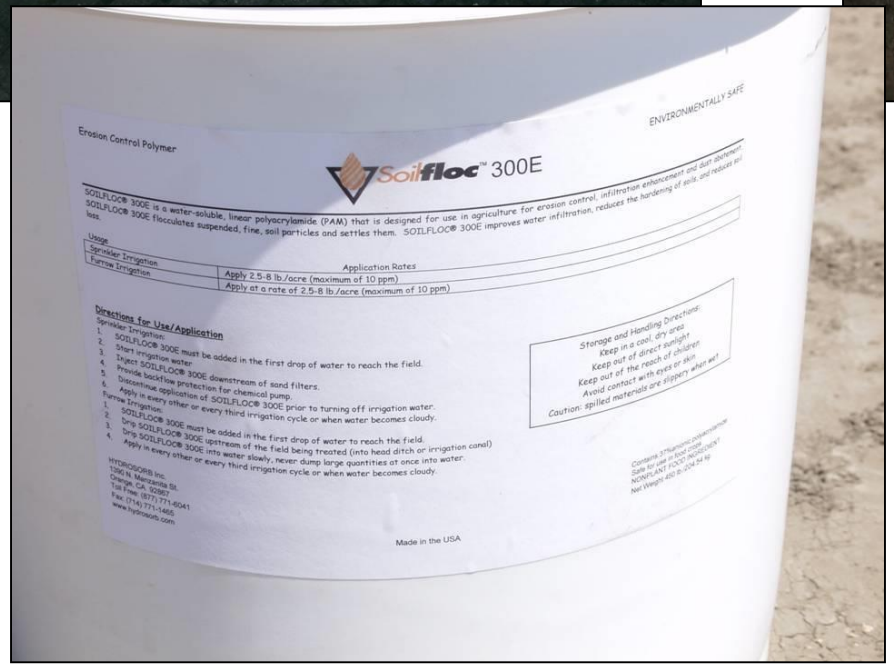
Pesticide 96-Hour LC50 (ng/L)	Chlorpyrifos	Bifenthrin	Fipronil	Imidacloprid
Fathead Minnow	122,000	4,850	398,290	?
Water Flea	54	142	17,700	??
Amphipod	86	9.3	728	65,430
Midge Fly Larva	290	69	32.5	2,650

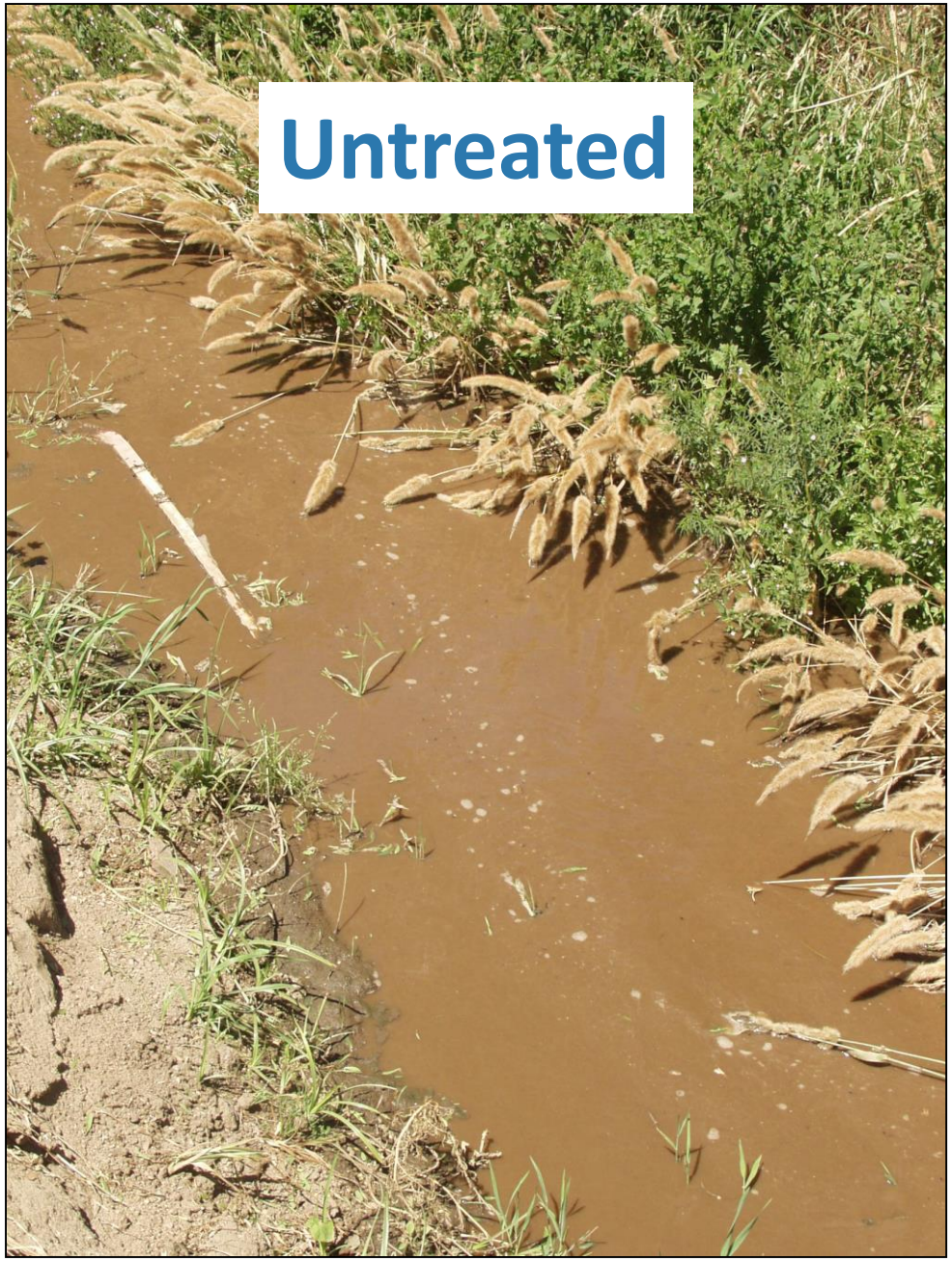
BMP's for runoff treatment:

- Sediment-Bound Insecticides:
  - Retention ponds
  - Vegetated treatment systems
  - Use of Polyacrylamide (PAM) to reduce suspended sediments
- More Water-Soluble Insecticides:
  - Apply tailwater to non-cropped areas
  - Vegetated treatment systems
  - Enzyme treatment (e.g., Landguard)

Retention Pond

Polyacrylamide (PAM)




Untreated


PAM-Treated

Vegetated Treatment System (Pennywort)

BMP Effectiveness – Ponds

- **Two-Pond Study**
- **Chemistry**
  - Some pyrethroid reductions up to 100% in water
  - Other pesticide reductions 20 - 90%
- **Toxicity**
  - 100% mortality to water fleas
  - 100% amphipod mortality at inlet, 72% mortality at outlet

Hunt et al. 2008

Vegetated Waterways

BMP Effectiveness – Integrated Vegetated Ditch

- **Configuration**
  - Sedimentation Basin (100 ft)
  - Vegetated Section (764 ft)
  - Landguard OP-A Treatment (108 ft)
- **Chemistry and Toxicity**
  - Organochlorines reduced >90%, pyrethroids up to 100%, chlorpyrifos up to 60% in water
  - Landguard OP-A enzyme removed diazinon
  - 88% average water flea survival after Landguard OP-A treatment

Anderson et al. 2009, 2011

BMP Effectiveness – Integrated Vegetated Ditch

- Adjustable volume and retention time, pennywort and grass vegetation, Landguard
- Organochlorines reduced up to 100%, some pyrethroids up to 100% in water
- Organophosphate concentrations & toxicity removed

Anderson et al. 2011, Phillips et al. 2012,

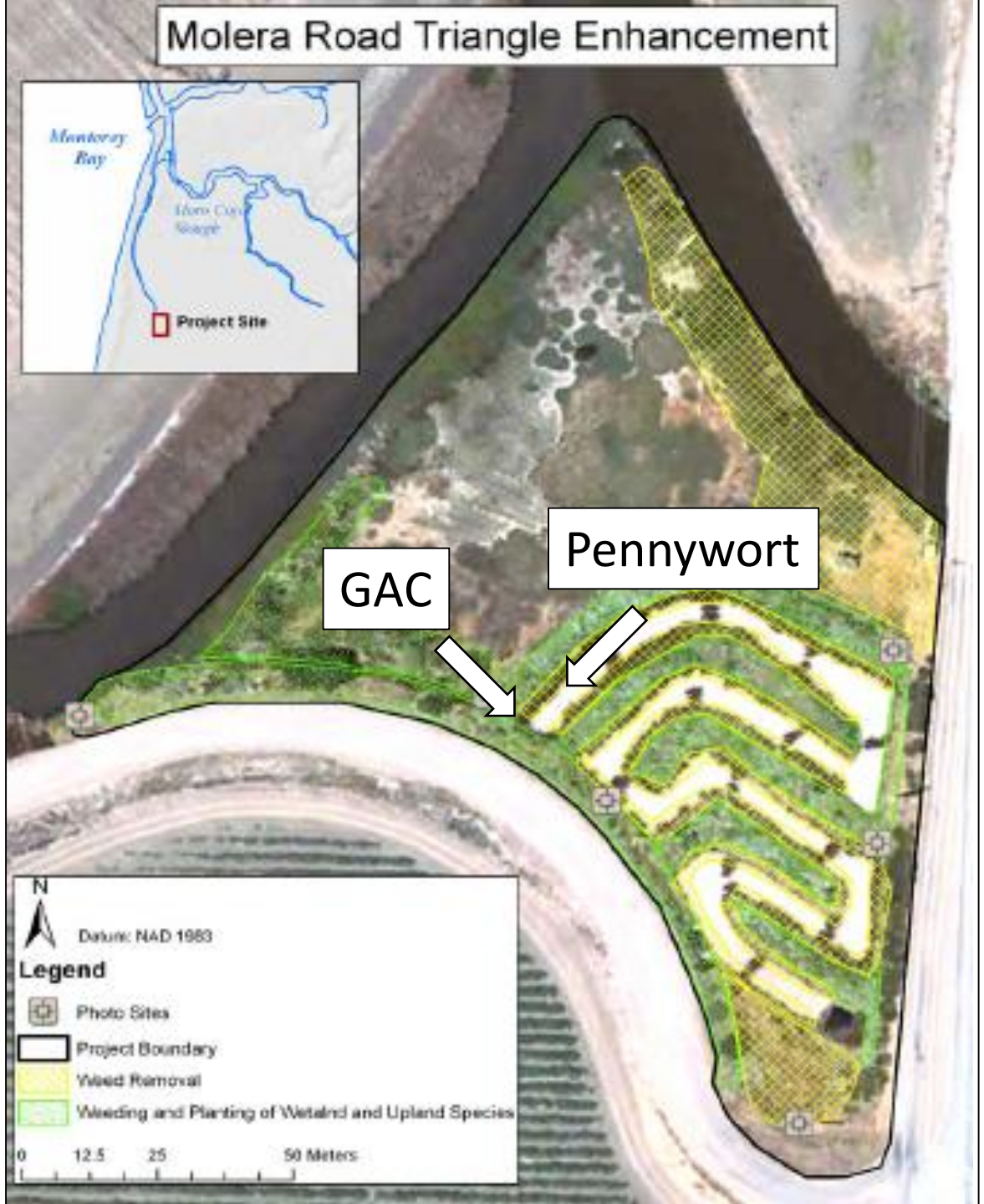
BMP Effectiveness – Integrated Vegetated Ditch

- Organophosphate mitigation tested with simulated chlorpyrifos-spiked irrigation
- Two simulated flow rates: 50 gpm and 100 gpm
- Vegetated with native grass (red fescue), and include installations of compost and granulated activated carbon in mesh enclosures
- Chlorpyrifos load reduced by 98% at low flow, 94% at high flow
- GAC in vegetated ditch removed additional 4-8%, depending on flow

Phillips et al. 2017

Vegetated System – Concerns

- Food Safety
  - Mammal presence (pathogen vectors)
    - Vegetation choice & fencing
- Cost & Maintenance
  - Ditch Construction - ~$10,100 (grading, seeding, irrigating, & maintaining)
  - Carbon – New GAC and disposal: $350-550 for two 55-gallon drums
    - Bulk ~$1-2 per pound
  - Mesh filter material: ~$100 per 130 ft roll


Molera Road Triangle Enhancement
Monterey Bay
Project Site
GAC
Pennywort
N
Datum: NAD 1983
Legend
Photo Sites
Project Boundary
Weed Removal
Weeding and Planting of Wetalnd and Upland Species
0
12.5
25
50 Meters

Aerial Views

Summary: On-Farm Management

- Retention Pond
  - Polyacrylamide (PAM)
- Integrated vegetative treatment system
  - Sedimentation basin
  - Vegetated ditch
  - Polishing step:
    - GAC (or Biochar?)
    - Enzyme treatment