Optimization of an Integrated Vegetated Treatment System and Evaluation of Landguard A900 Enzyme

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Background

- Monterey County agriculture = $4 billion in 2009
- Lettuce products = $1.4 billion in 2009
- “The Salad Bowl of the World”
- This equates to pesticide runoff and adverse effects in receiving systems
- Evidence of impacts and regulations have motivated growers to experiment with various management practices to reduce and treat runoff

Management Practices

Floating Vegetation (Pennywort)

No Vegetation

Management Practices

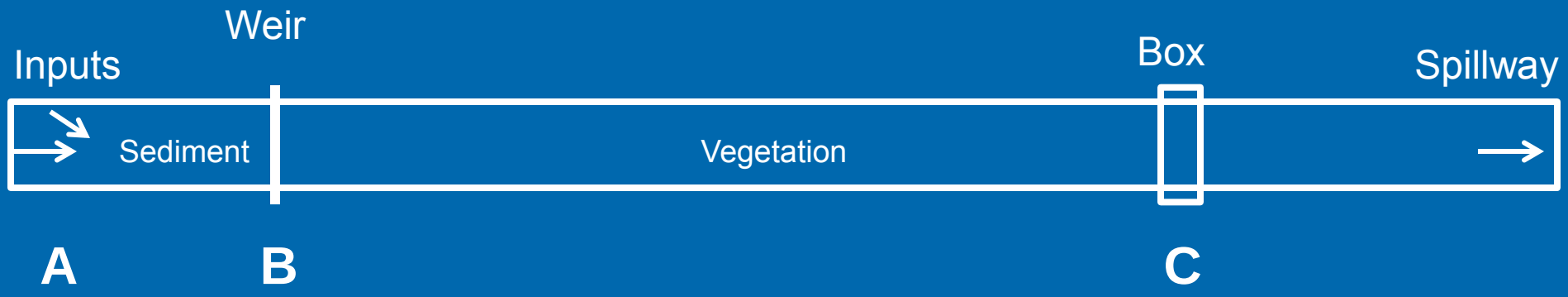
Integrated Vegetated Treatment System (VTS)

Sedimentation (40m)

Vegetation (170m)

Volume Control

Integrated Vegetated Treatment System (VTS)



- Water drains from approximately 120 acres
- Weir holds back water for sedimentation
- Box can be adjusted to hold back water in vegetation
- Spillway drains to Lateral Ditch
- Landguard enzyme was introduced at the weir, but in previous study the enzyme was introduced at C

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PESTICIDE AND TOXICITY REDUCTION USING AN INTEGRATED VEGETATED TREATMENT SYSTEM

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Abstract—The California, USA, central coast is one of the most productive agricultural areas in the world, and numerous stakeholders are working there to implement conservation practices to reduce contaminated runoff. Practices include vegetated treatment systems (VTS) designed to promote contaminant reduction and breakdown. The current study evaluated the effectiveness of a vegetated drainage ditch incorporating a sedimentation basin, a vegetated section, and a Landguard organophosphate-A (OP-A) enzyme dosing system. The VTS was constructed on a working farm and was designed to remove organophosphate and pyrethroid pesticides, the primary pesticides causing toxicity in Salinas Valley watersheds. The present study was conducted during five separate irrigation events on tailwater runoff containing mixtures of pesticides and suspended sediments. Water samples were collected at four stations within the system, and these were subjected to chemical analyses and tested for toxicity to *Ceriodaphnia dubia*. All inflow samples were highly toxic to *C. dubia*, and this was largely because of diazinon. Treatment of diazinon-contaminated runoff was only partially effective using aquatic vegetation. All diazinon remaining after vegetated treatment was effectively removed after treatment with the Landguard OP-A enzyme. Chemical analysis of the VTS water samples showed that pyrethroid and organochlorine pesticide concentrations in water were greatly reduced in the sedimentation section of the ditch, and these pesticides were further reduced in the vegetated section of the ditch. The overall conclusion from these analyses is that the VTS was effective at reducing the more hydrophobic organochlorine and pyrethroid pesticides from water. The water-soluble pesticide diazinon was not sufficiently removed during the VTS residence times observed in this study; however, residual diazinon was effectively removed using Landguard OP-A. Environ. Toxicol. Chem. 2011;30:1036–1043.

Keywords—Agriculture Pesticides Treatment Systems Toxicity

Landguard™ A900

Developed by Commonwealth Scientific and Industrial Research Organization (CSIRO), Australia's national science agency.

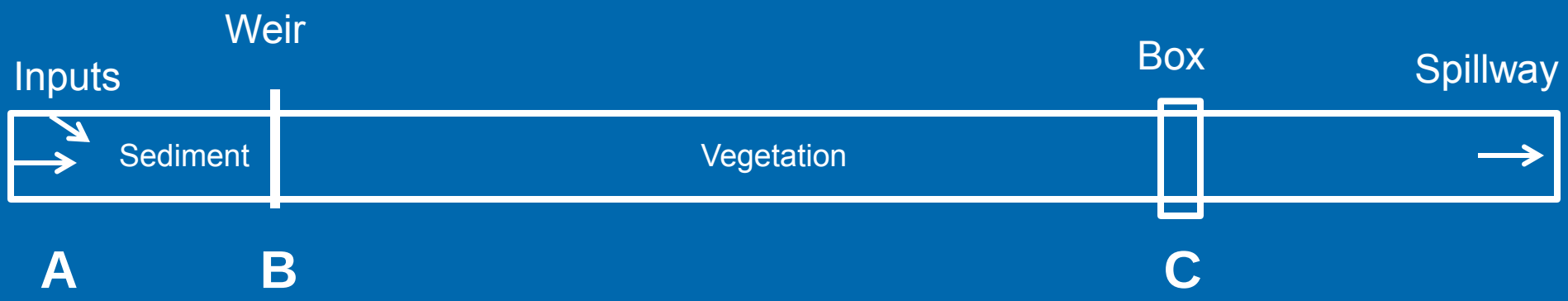
Derived from bacteria originally isolated from soil and cultured on a large scale.

Lyophilized enzyme is mixed with water and added directly to runoff.

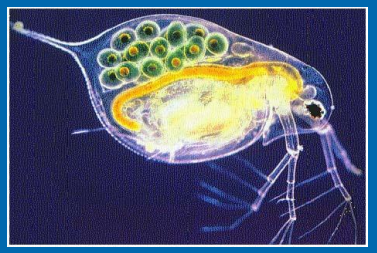
Landguard Application

Project Goals

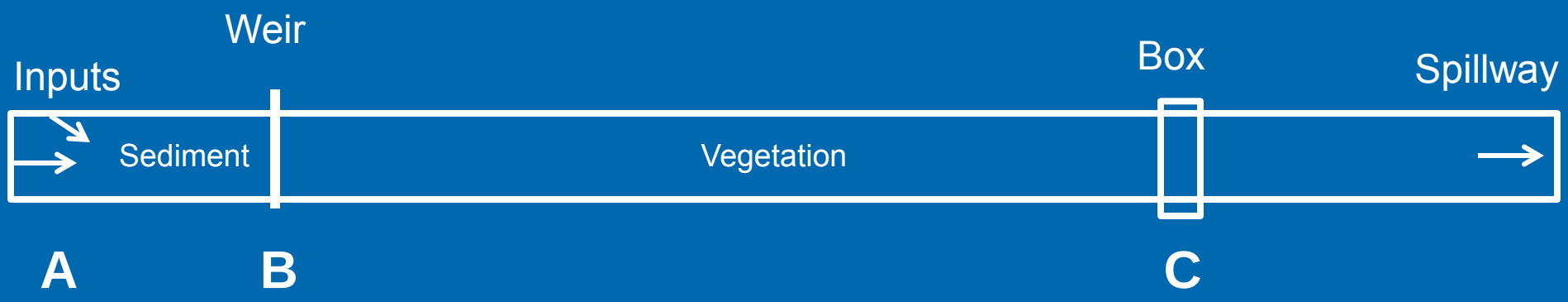
- Refine the VTS design by measuring the performance of the vegetated component under low volume and high volume scenarios.
- Optimize the dose and mixing time of the Landguard enzyme through laboratory spiking experiments.
- Test optimal Landguard dose in the refined VTS and under conditions with high discharge and short mixing times in a larger drainage.



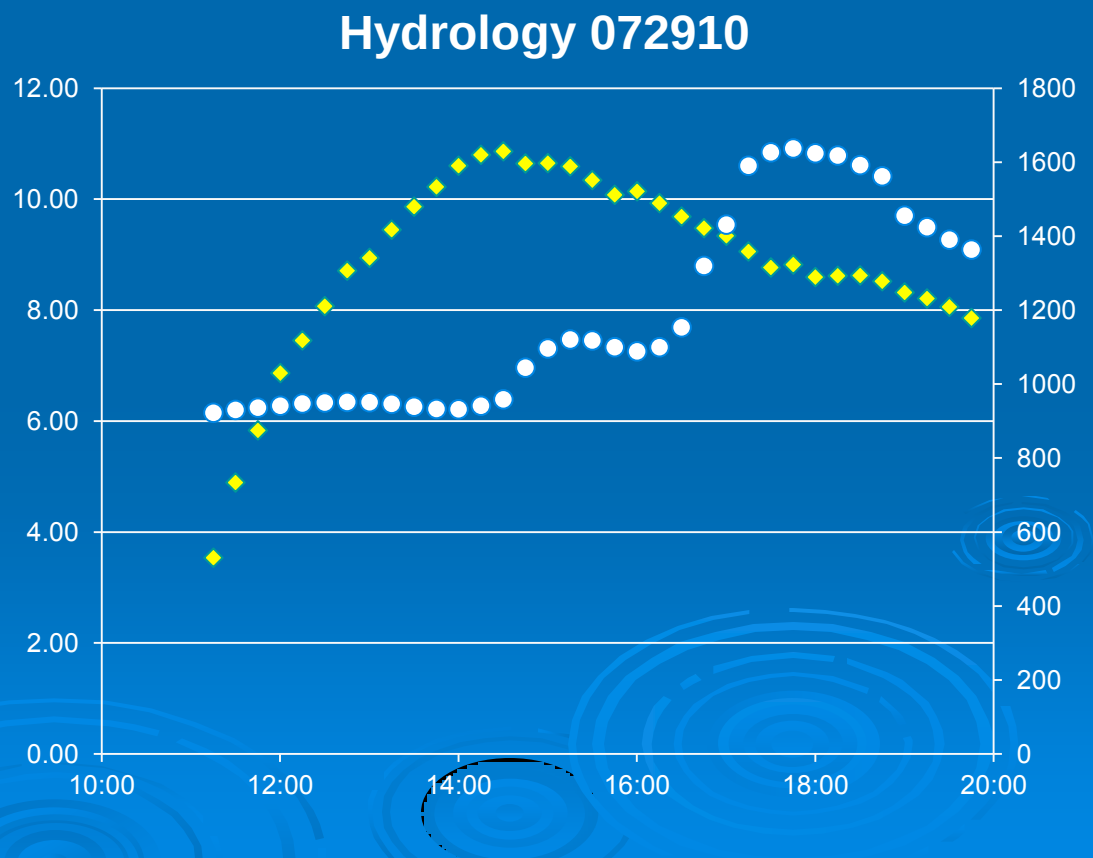
- Water samples collected at A, B and C
- Samples tested for toxicity with *Ceriodaphnia dubia* and *Hyalella azteca* (96 hour acute tests)



- Samples analyzed for chlorpyrifos and diazinon with ELISA (also measure nitrate, phosphate and turbidity)
- Some samples analyzed for organophosphates, pyrethroids, and organochlorines



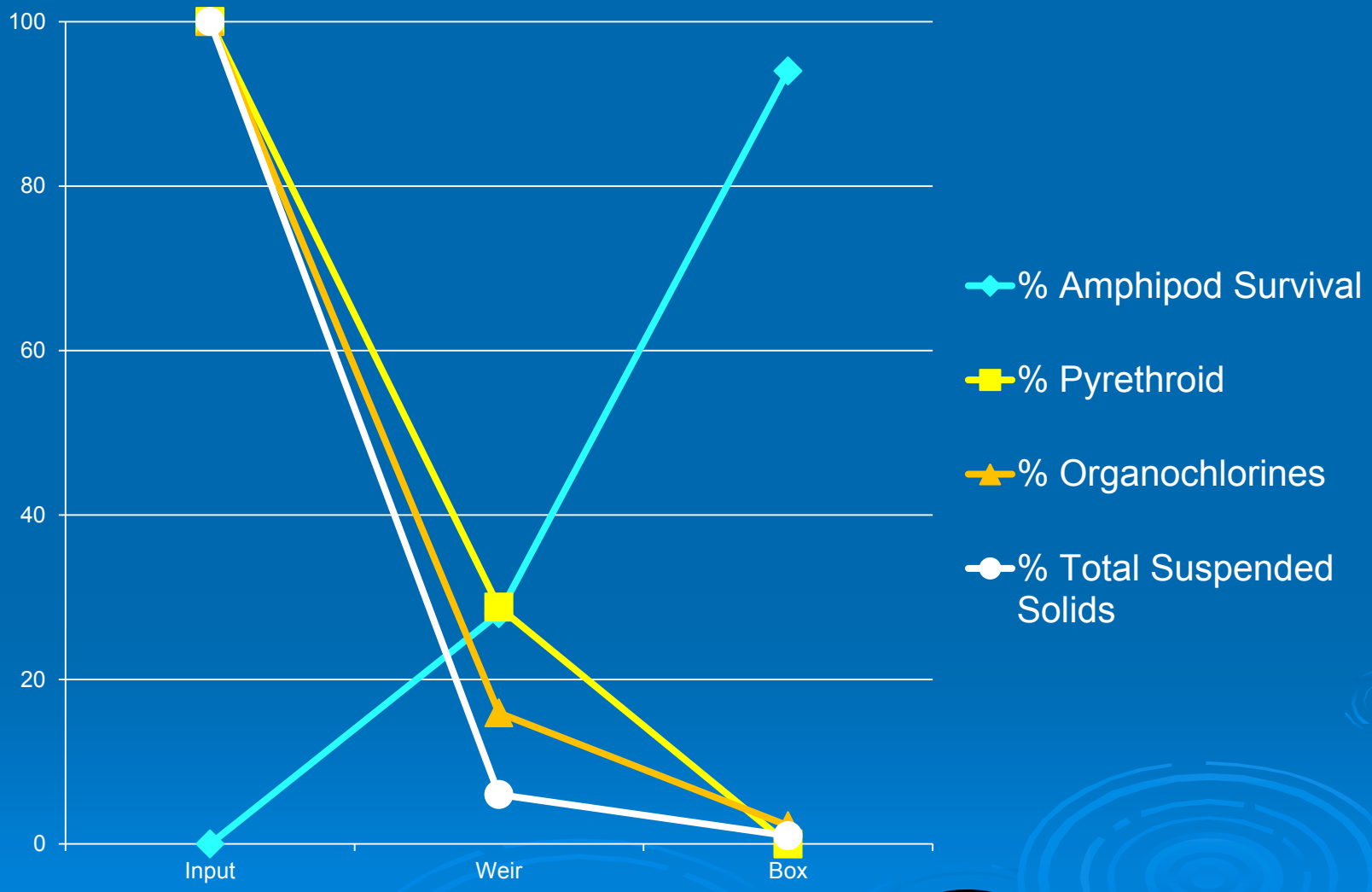
Tracking a Pulse of Water



Low and High-Volume Trials

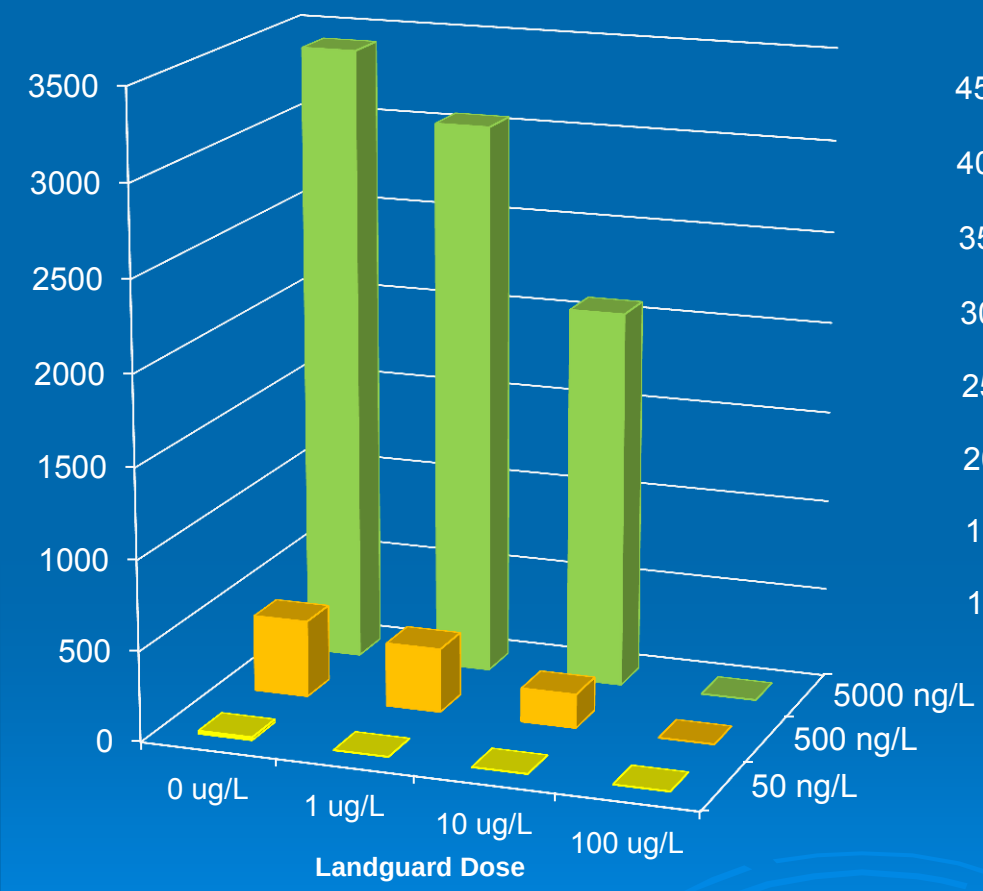
	Daphnid Surv.	Amphipod Surv.	TSS	Cyhalo-thrin	Per-methrin	4,4'-DDT	Diazinon	Mala-thion
Input	92	0	3890				<RL	
Weir	0	0	32.0				<RL	
Box	0	20	17.5				<RL	
Input	80	80	39.0	ND	ND	6.48	26	Trace
Weir	44	80	39.0	ND	ND	3.27	24	Trace
Box	65	93	17.0	ND	ND	2.51	29	Trace
Input	92	20	570	5.03	26.9	119.3	ND	ND
Weir	100	48	85.5	ND	39.2	43.9	ND	Trace
Box	97	72	11.6	ND	25.1	ND	12	80
Input	47	2	1340				ND	
Weir	93	24	99.3				ND	
Box	87	96	20.3				ND	
Input	0	0	3764	33.5	68.1	108.5	ND	ND
Weir	88	28	234	11.1	18.1	42.3	ND	ND
Box	88	94	30	ND	ND	ND	ND	ND
Input	52	6	3164	123	107	85	ND	ND
Weir	92	18	74.7	27.8	13.1	15.6	18	Trace
Box	96	62	15.7	5.71	ND	ND	17	Trace

High-Volume Trial 3

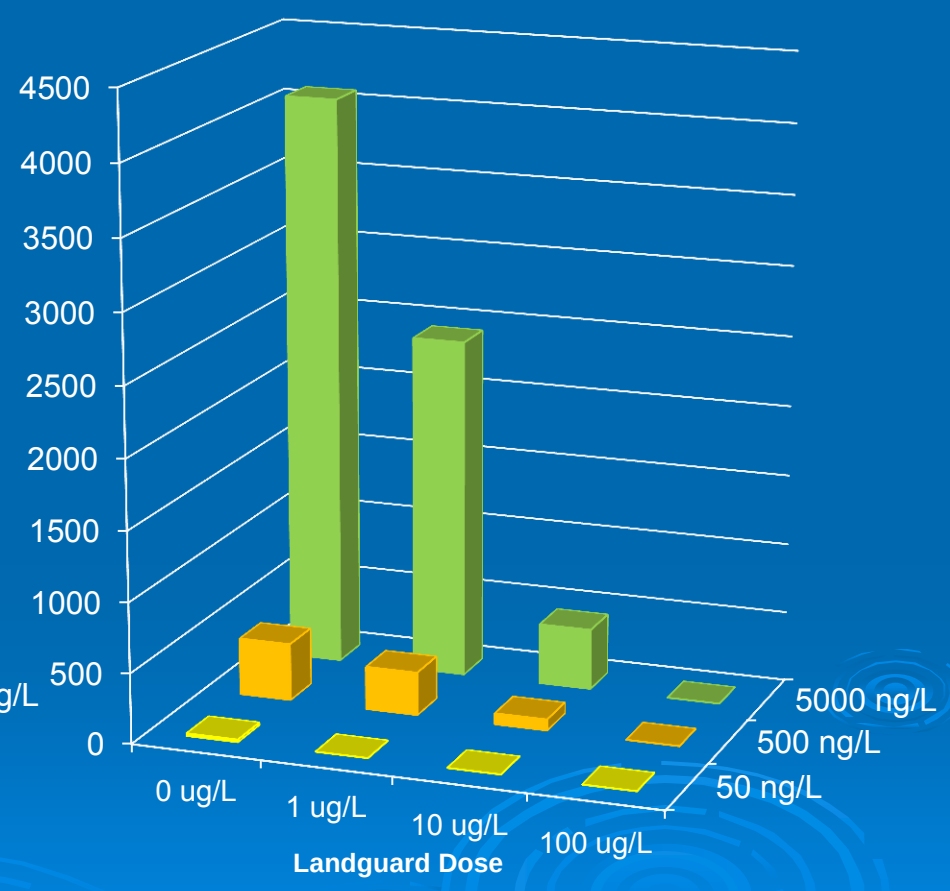


Landguard Laboratory Efficacy Tests - Chlorpyrifos

One Hour

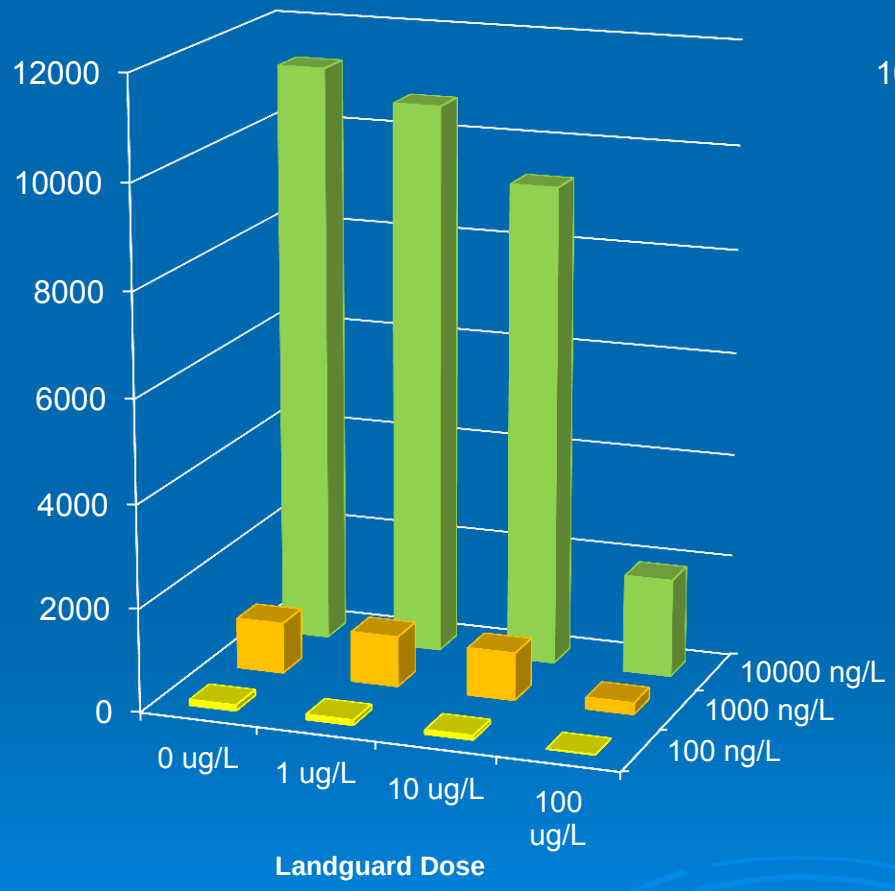


Three Hour

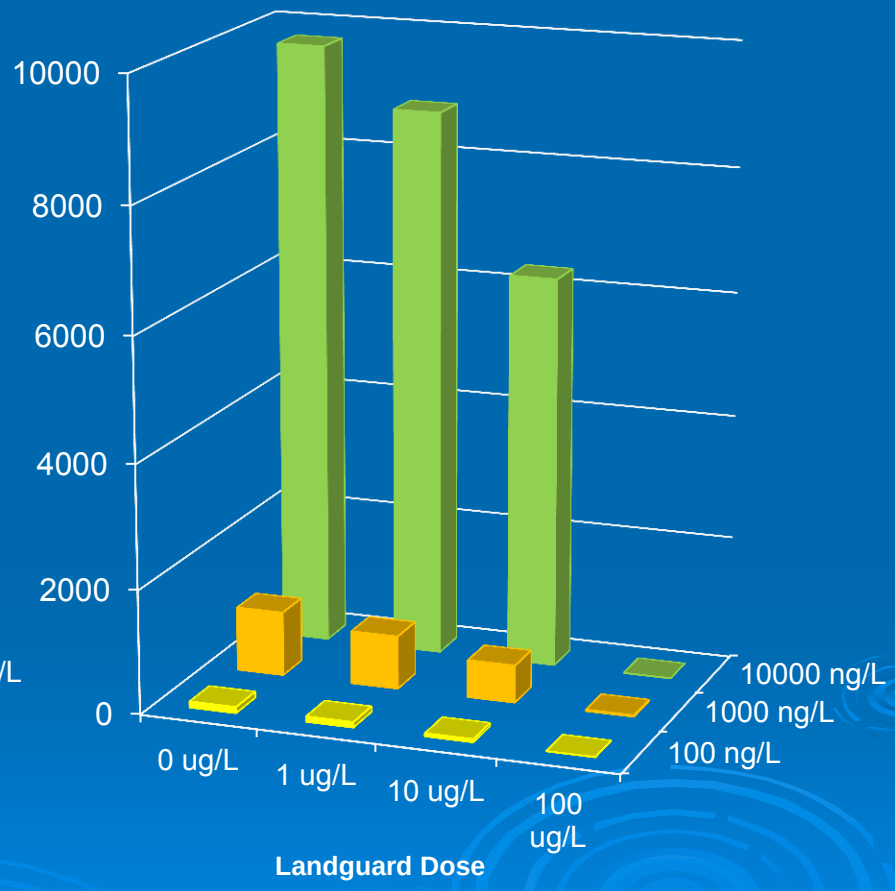


Landguard Laboratory Efficacy Tests - Diazinon

One Hour



Three Hour



Landguard Application - VTS

Station	Daphnid % Survival	Amphipod % Survival	Cyhalothrin (ng/L)	Permethrin (ng/L)	Malathion (ng/L)	Turbidity (NTU)
Weir	**0**	**0**	**231**	2.87	85	52
Box	84	**48**	**5.03**	ND	Trace	51
Weir	84	**13**	**8.2**	ND	Trace	103
Box	96	91	ND	ND	ND	15
Weir	92	**12**				237
Box	100	92				31
		Daphnid LC50	200	250	2120	
		Amphipod LC50	2.3	21.1		

Lateral Ditch

- Larger drainage with approximately 20 times the discharge of the VTS.
- Drains several properties and hundreds of acres.
- Approximately 300m long with a 2m fall.
- Deeply incised and essentially unvegetated.
- Pulse transit times of about 10 to 45 minutes.

Landguard Application – Lateral Ditch

Station	Daphnid % Survival	Amphipod % Survival	CHL (ng/L)	DIA (ng/L)	DIM (ng/L)	MAL (ng/L)	MEP (ng/L)	CYH (ng/L)
Weir	0	0	1558	130				
Bottom	85	8	<RL	<RL				
Weir	0	0	388	ND				
Bottom	92	4	ND	ND				
Weir	0	80	76	ND	371	Trace	405	ND
Bottom	76	94	ND	ND	405	Trace	ND	ND
Weir	0	0	95	ND	ND	84	ND	8.77
Bottom	94	71	ND	ND	ND	81	ND	ND
Weir	0	42	63	ND	ND	82	ND	ND
Bottom	92	66	ND	ND	ND	ND	ND	ND
		Daphnid LC50	53	350		2120		200
		Amphipod LC50	86	6510				2.3

Percent Reduction

Parameter	Current Study	Previous Study
CHL and DIA (with enzyme treatment)	100	100
Other OPs(with enzyme treatment)	Mixed	NA
Organochlorines	97-100	91
Pyrethroids	98-100 (21)	100
Turbidity	98-100	89-94

Are the post-VTS Concentrations Low Enough?

Parameter	Ag Waiver Objective	Current Study (no enzyme)	Current Study (with enzyme)
Chlorpyrifos	25 ng/L	13.7 ng/L	ND
Diazinon	140 ng/L	19.3 ng/L	ND
Nitrate	30 mg/L	23.1 mg/L	
Turbidity (narrative)	25 NTU	41.8 NTU	
Toxicity	None	Some	

Next Steps

- CSIRO is developing a time-release enzyme application for organophosphates that will need evaluation
- CSIRO is also developing similar applications for synthetic pyrethroid pesticides
- Outreach

Acknowledgements

- Monterey County Resource Conservation District
- California Department of Pesticide Regulation
- U.S. Department of Agriculture
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- CSIRO – Commonwealth Science and Industrial Research Organization