Institute for **Water** and **Environmental** Resource Management

Towards water quality guidelines for groundwater ecosystems

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Water Quality Guidelines

- ANZECC & ARMCANZ water quality guidelines use a risk based approach
- Guidelines are ‘Trigger values’ to prompt further action or investigation
- Focus on site specific or ecosystem specific guidelines

Water Quality Guidelines

- Different guidelines for different uses
- Some may be suitable for GDEs
  - Particularly those with surface expression
- Because data for animals in the ecosystems used to derive guidelines

Existing protection

GDE	Existing Guidelines	Level of Protection
Terrestrial vegetation	Primary Industries (Irrigat. & general use)	Unknown
River base flow systems	Aquatic ecosystems	Probably sufficient
Aquifer and cave ecosystems	Aquatic ecosystems	Unknown
Wetlands	Aquatic ecosystems	Probably sufficient
Terrestrial fauna	Primary Industries (Livestock drinking)	Unknown
Estuarine and near-shore marine	Aquatic ecosystems	Probably sufficient

Ignorance is bliss!!

- Assumed that surface guidelines will protect groundwater ecosystems

…but there are insufficient data to make this assumption!

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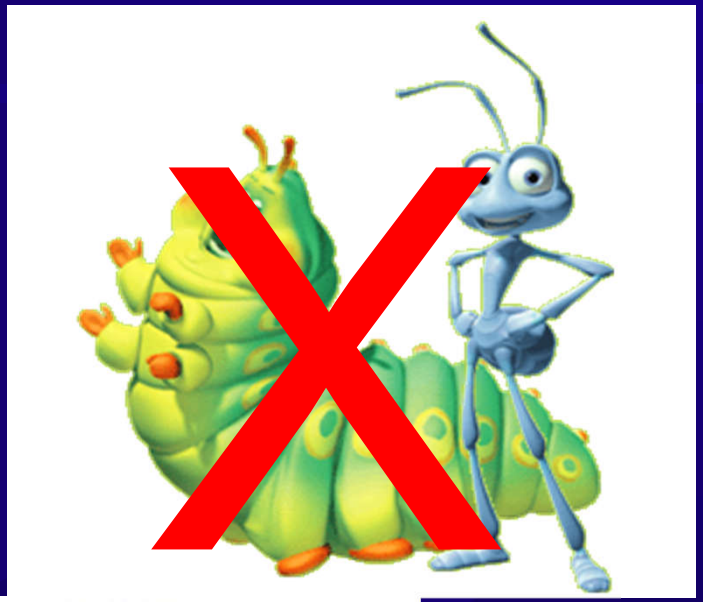
Water Quality Guidelines

- TVs for phys-chem stressors based on expert opinion and 80th percentile of reference site data
- Derivable from GW management plans?
- Guidelines for toxicants more problematic
  1. Doesn't include GW bugs
  2. Includes bugs that are not in GW ecosystems

Groundwater fauna

- Truncated biodiversity
  - Crustaceans
  - Rotifers
  - Oligochaetes
  - Nematodes
  - Microbiota

As a general model… There are no….



We're a little bit different….

- Groundwater ecosystems contain a different suite of organisms to surface ecosystems

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Aims

- Assess the need for water quality guidelines specific for groundwater ecosystems

1. Compare the sensitivity of surface and groundwater fauna

1. Provide a preliminary risk assessment for groundwater fauna in Australia

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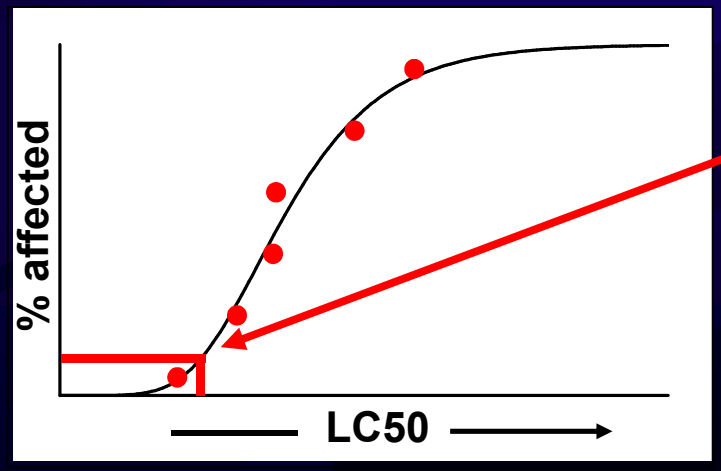
1. Comparing sensitivity

- Species sensitivity distributions (SSDs) used to derive water quality guidelines
- Fits a statistical distribution function to ranked species toxicity data



PC95 Value
Protects 95% of species

1. Constructing SSDs

- Australian guidelines use Burr Type III distribution
- Burr Type III approximates common distributions eg log-normal, log-logistic and Weibull
- Calculate PC95 values + 95% CIs

1. Comparing GW & SW sensitivity

- 48 - 96 h LC50 and EC50 values used
- Geometric mean used where multiple data for a taxon
- Laboratory toxicity data:
  - Water Quality Guideline Database for Toxicants
  - AQUIRE database
  - Maltby et al 2003
  - Notenboom 1992

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1. Toxicity Data

- Few data for *true* groundwater taxa
- Data for groundwater dwelling orders used as surrogate

Assumes there is no difference in the sensitivity of surface and groundwater organisms of the same taxonomic group

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1. Data classification

- ‘Groundwater’ taxa
  - Crustaceans
  - Rotifers
  - Annelids etc
- Surface water taxa
  - Fish
  - Insects
  - Plants/algae
  - Crustaceans
  - Rotifers
  - Annelids etc

Out of sight, out of mind….

- Groundwater ecosystems under threat
  - Water extraction
  - Contamination
- Over 34 pesticides in Australian groundwater
  - 19 herbicides
  - 14 insecticides
  - 2 fungicides

1. Pesticide data

- Sufficient toxicity data to derive SSDs for:

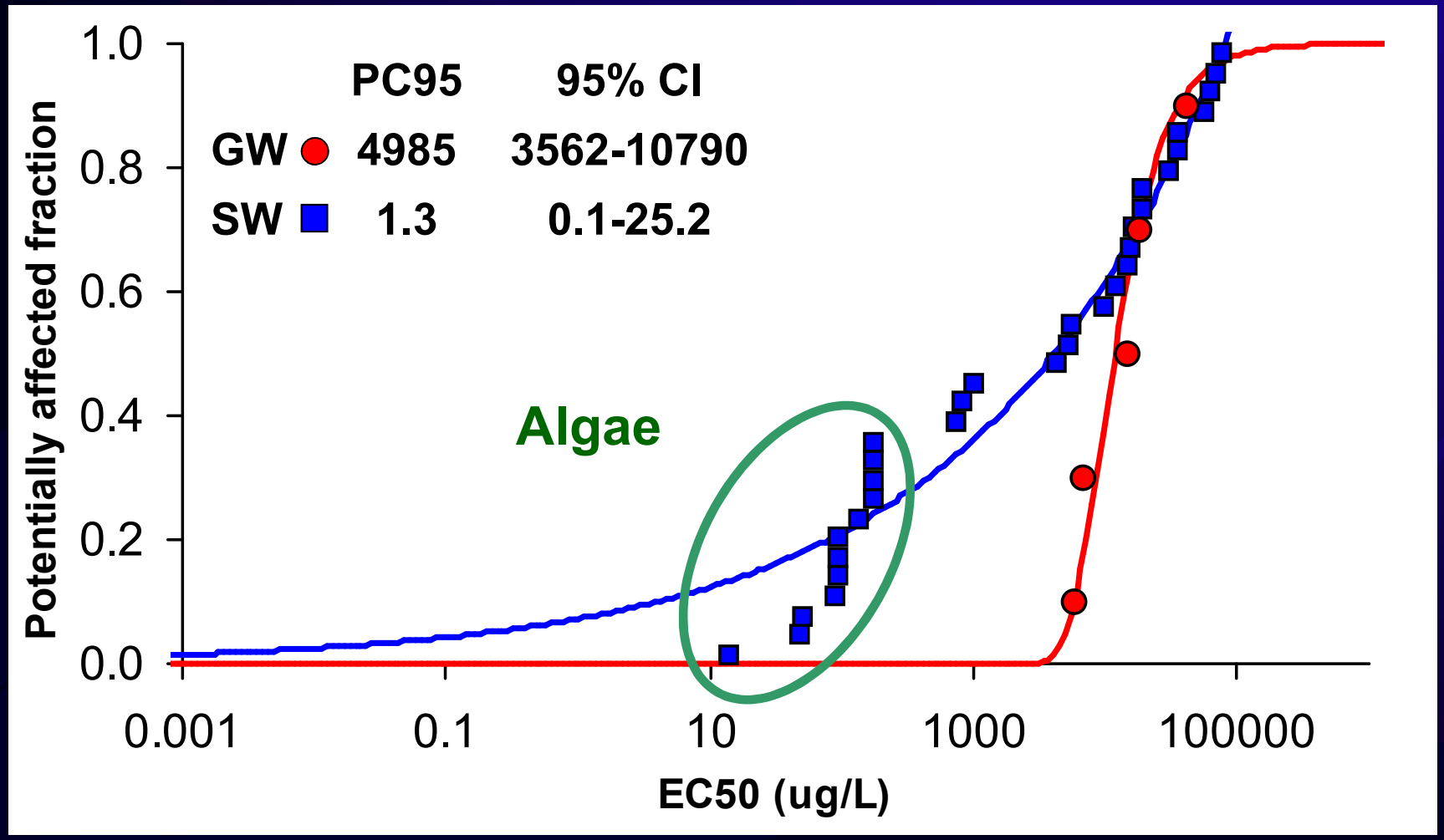
Herbicides	Insecticides
2,4-D	Chlordane
Atrazine	Chlorpyrifos
Trifluralin	DDT
	Diazinon
	Dimethoate
	Heptachlor
	Lindane
	Malathion

1. Results

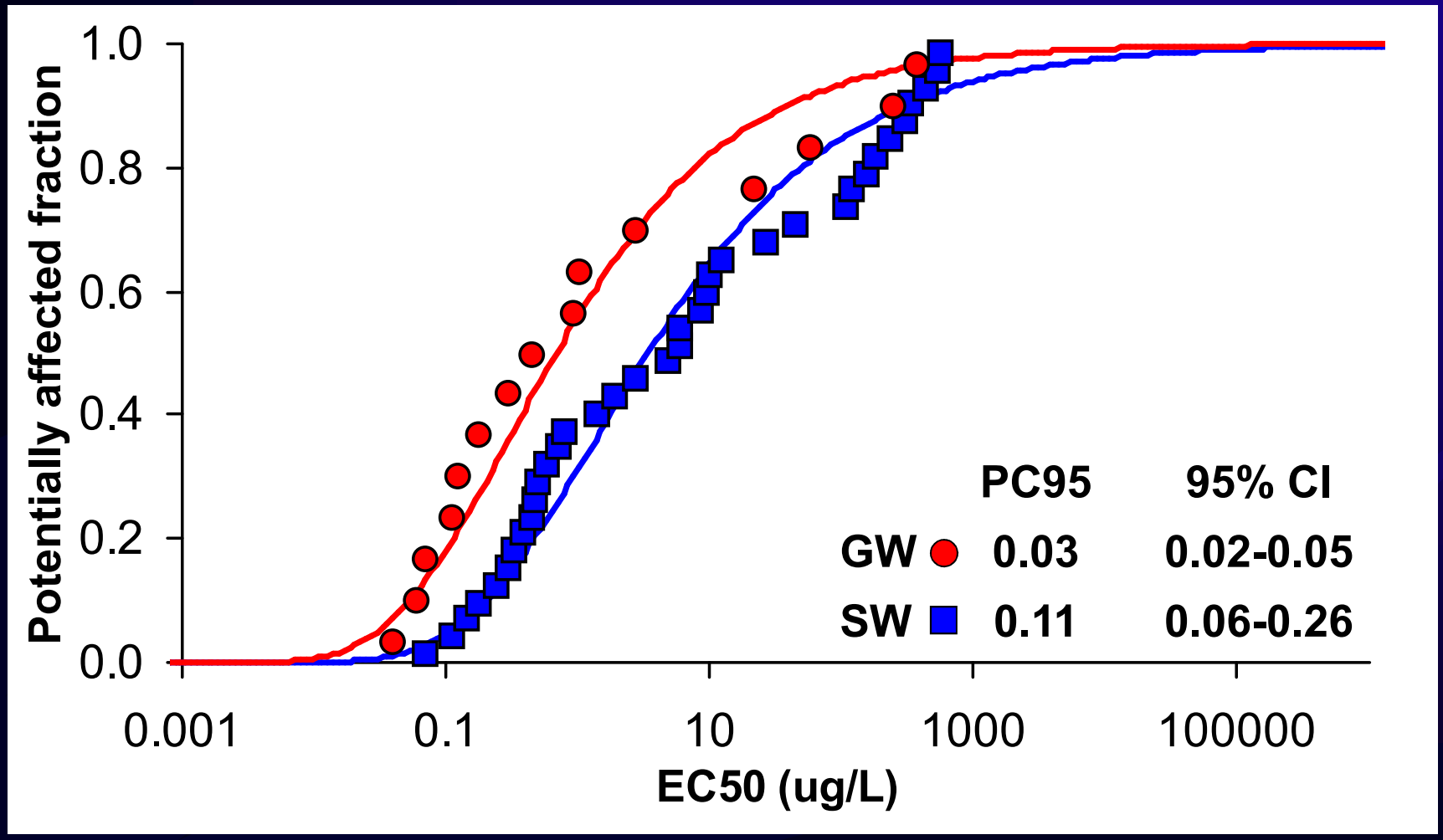
- No significant difference in PC95 values for most pesticides

- Except for….

1. Atrazine



1. Chlorpyrifos



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1. From SSDs to trigger values

- When using acute toxicity data a safety factor is applied to the PC95 value

- Gives water quality guideline Trigger Value (TV)

1. Surface fauna most sensitive

Pesticide	GW TV	SW TV
Chlordane	2.5	0.11
DDT	0.02	0.01
Diazinon	0.05	0.01
Dimethoate	0.07	0.04
Atrazine	**247**	**0.07**

All values in µg/l

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1. GW fauna most sensitive

Pesticide	GW TV	SW TV
2,4-D	167	332
Trifluralin	3.1	7.2
Heptachlor	0.12	0.24
Lindane	0.16	0.18
Malathion	0.02	0.03
Chlorpyrifos	**0.003**	**0.01**

All values in µg/l

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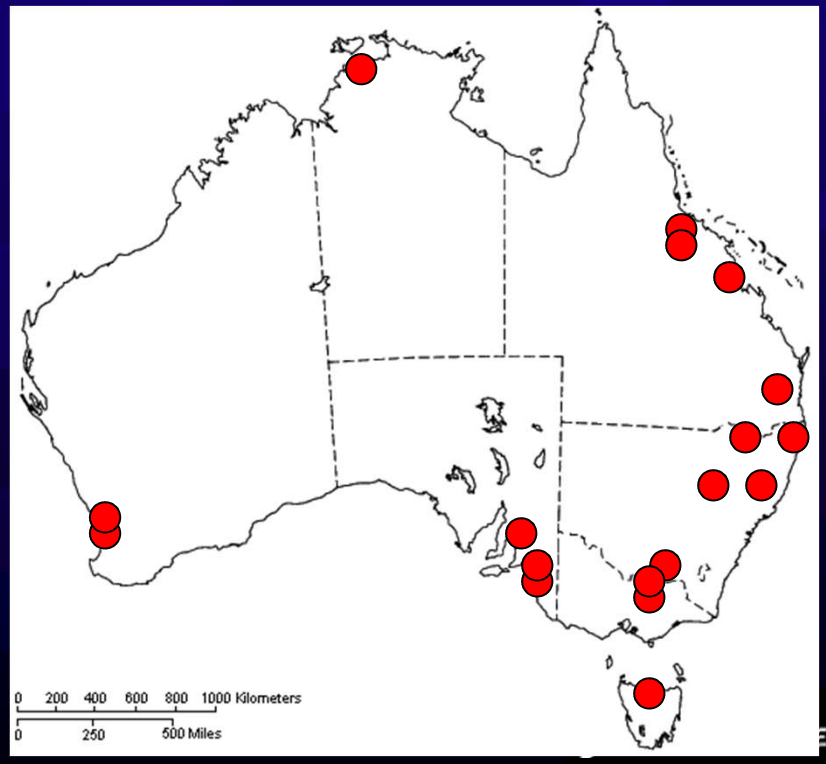
1. Summary

- Truncated biodiversity causes little difference in the sensitivity
  - Except for Atrazine & Chlorpyrifos
- Several groundwater TVs were less than surface water TVs
- Sensitivity may be toxicant specific

2. Risk assessment

- Comparing trigger values to groundwater contamination data
- Peak concentrations from >28 studies across Australia



2. Herbicide Risk assessment

Pesticide	GW TV	GW conc
2,4-D	167	0.39
Atrazine	247	14
Trifluralin	3.1	0.07

All values in µg/l

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2. Insecticide Risk assessment

Pesticide	GW TV	GW conc
Chlordane	2.5	0.004
Chlorpyrifos	0.003	2.4
DDT	0.02	1.3
Diazinon	0.05	4
Dimethoate	0.07	0.1
Heptachlor	0.12	0.003
Lindane	0.16	0.006
Malathion	0.02	Trace

All values in µg/l

2. Risk assessment summary

- Current concentrations of pesticides in groundwater may be toxic to groundwater fauna

Points to ponder…..

- Limited data suggests *true* GW crustaceans are similarly or more sensitive than surface water crustaceans

- GW fauna particularly sensitive because:
  - Adapted to stable environment
  - Highly specialised
  - Low metabolic rates
  - Low densities
  - Low reproductive rates
  - Low migration potential

Highly susceptible

Slow recovery

Lower acute exposure – need chronic data

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Points to ponder.....

- Groundwater ecosystems are different!
  - No light
  - Low DO
  - High hardness & conductivity

- May affect toxicant fate and exposure

Points to ponder…..

- We know little of the biology & ecology of groundwater fauna

A conservative approach to setting water quality guidelines is needed!

- Should we use the PC95 or PC99 value?

"underground aquatic ecosystems and their novel fauna…should be given the highest level of protection"
(ANZECC & ARMCANZ 2000)

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Conclusion

- Groundwater fauna may be more or less sensitive than surface water fauna

- Current levels of GW contamination are likely to cause impacts to groundwater fauna

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Do we need water quality guidelines specific to groundwater ecosystems?

Yes!

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