



# Pharmaceuticals in the Environment: *What we know and need to know*

Environmental Health Summit  
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USGS Toxic Substances Hydrology Program

# Chemicals of Emerging Environmental Concern: *Emerging Contaminants*

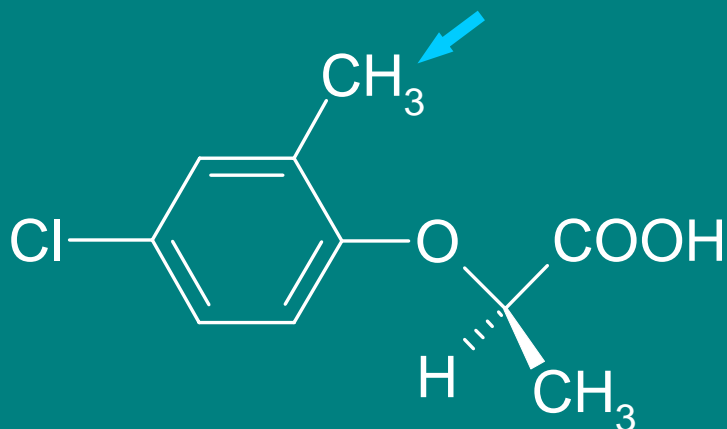
- Human Drugs
- Vet. Drugs
- Antibiotics
- Hormones
- Steroids
- Detergents
- Plastics
- Antioxidants
- Fire retardants
- Disinfectants
- Fumigants
- Fragrances
- Insecticides/  
Repellants

# Framing Research Questions

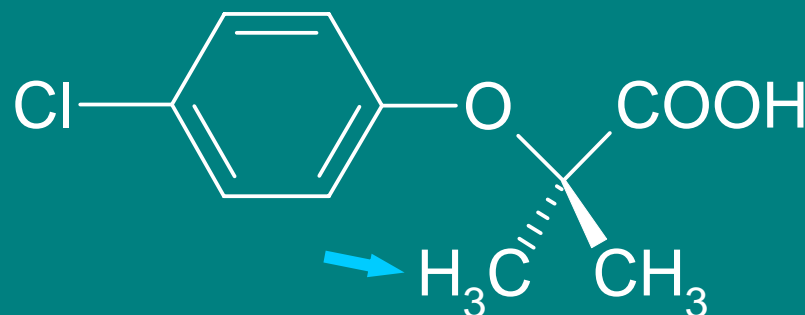
- *Are pharm's entering our environment?*
- *What are the sources (signatures) and are there sensitive settings?*
- *Do pharm's have adverse ecological health effects?*
- *Do pharm's persist to finished drinking water and are they a human health risk?*
- *How can we minimize their entry to the environment or remove them?*

# *Are pharm's entering our env't?*

Clofibric Acid found in the North Sea.



Mecoprop  
(Pesticide)



Clofibric Acid  
(Cholesterol Drug)

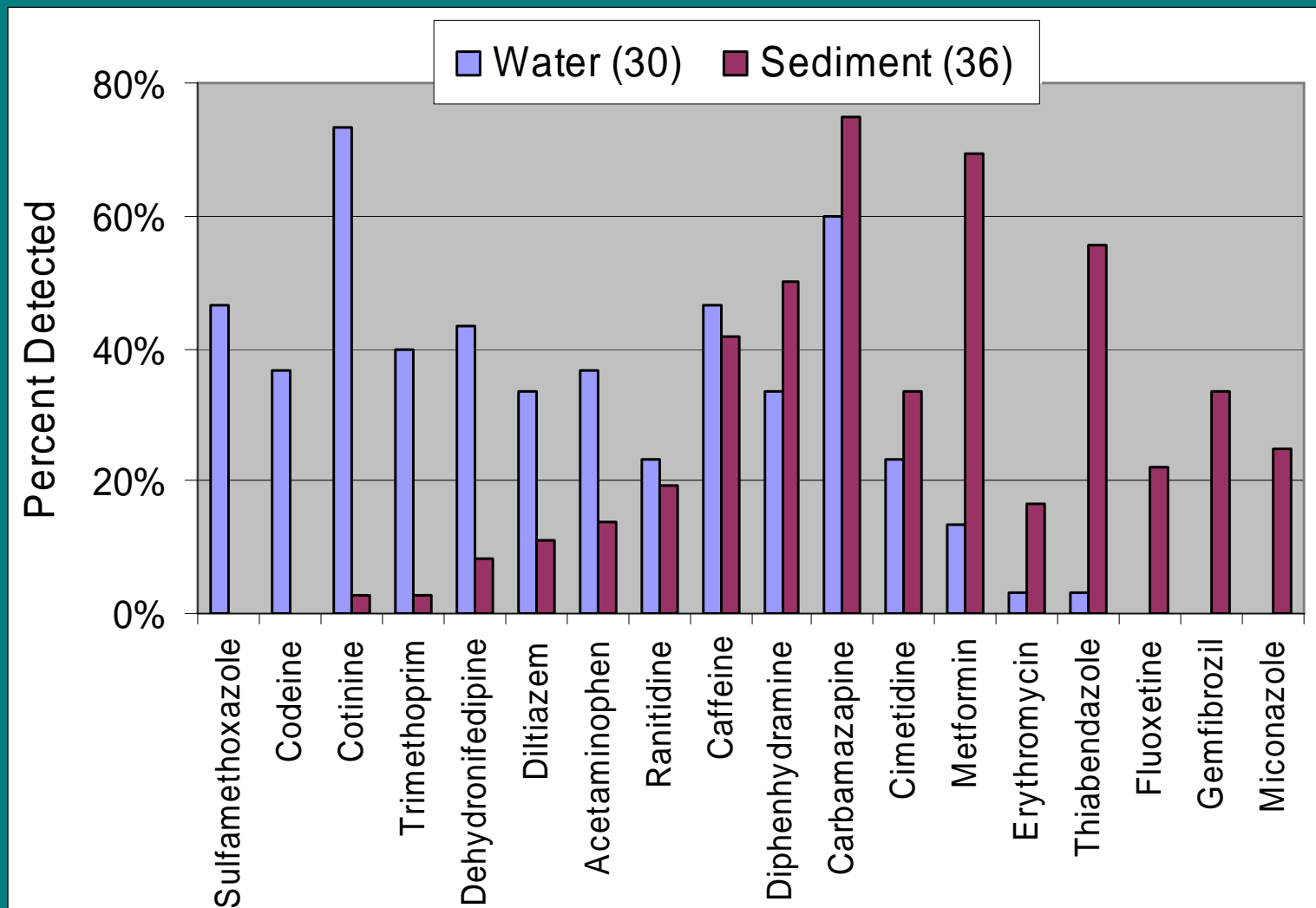
# Are pharm's entering our environment?

## Pharm's in Susceptible Settings

- Present in water at sub-ppb conc.'s.
- Present as complex mixtures.
- Entering via human & animal waste pathways.



# Don't just look in the water!



# What are the sources?

## Human Waste

- WW Treatment Plants
- Land Application
- Domestic Septic Systems
- Landfills
- Industrial/Commercial Discharges
- Water Reuse



# What are the sources?

## Animal Waste

- Waste lagoons
- Land application
- Processing
- Aquaculture

### Manure (kg/day)

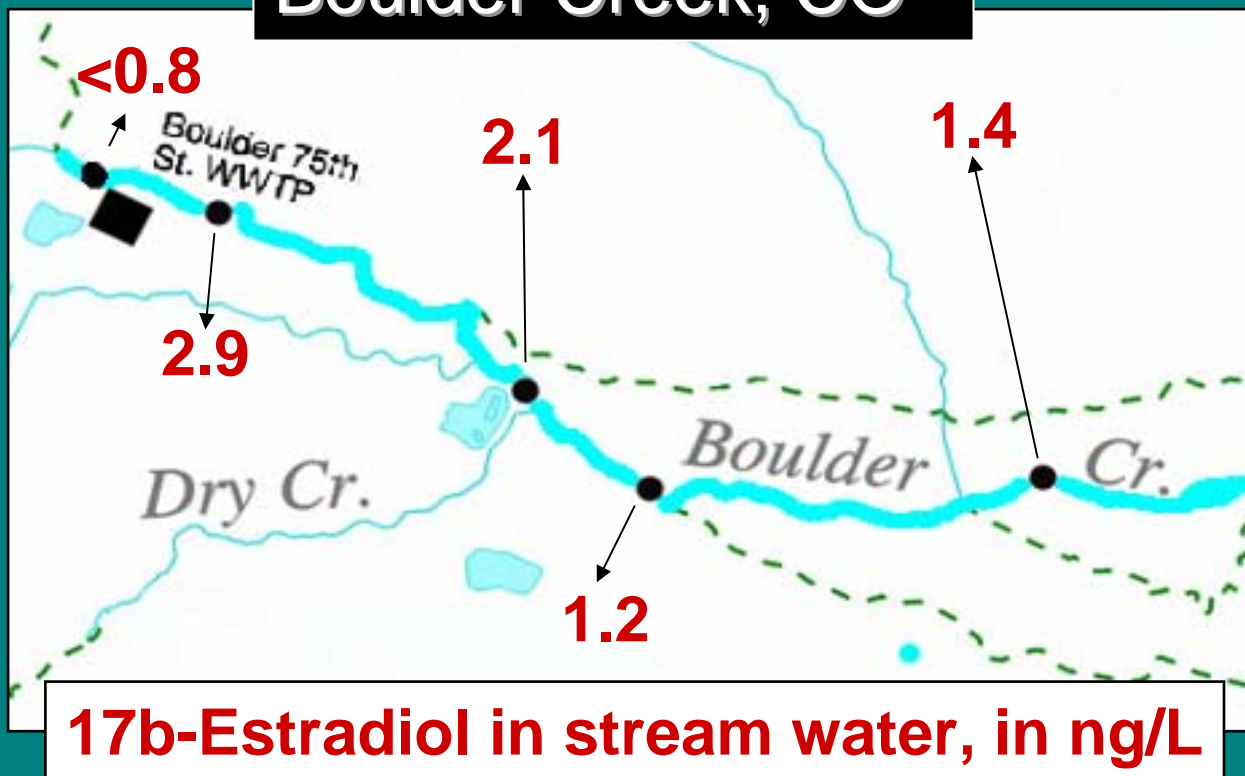
Human	1.5
Cow	30
Hog	4
Sheep	1.5
Chicken	0.14



# *Sensitive Env'l Settings?*

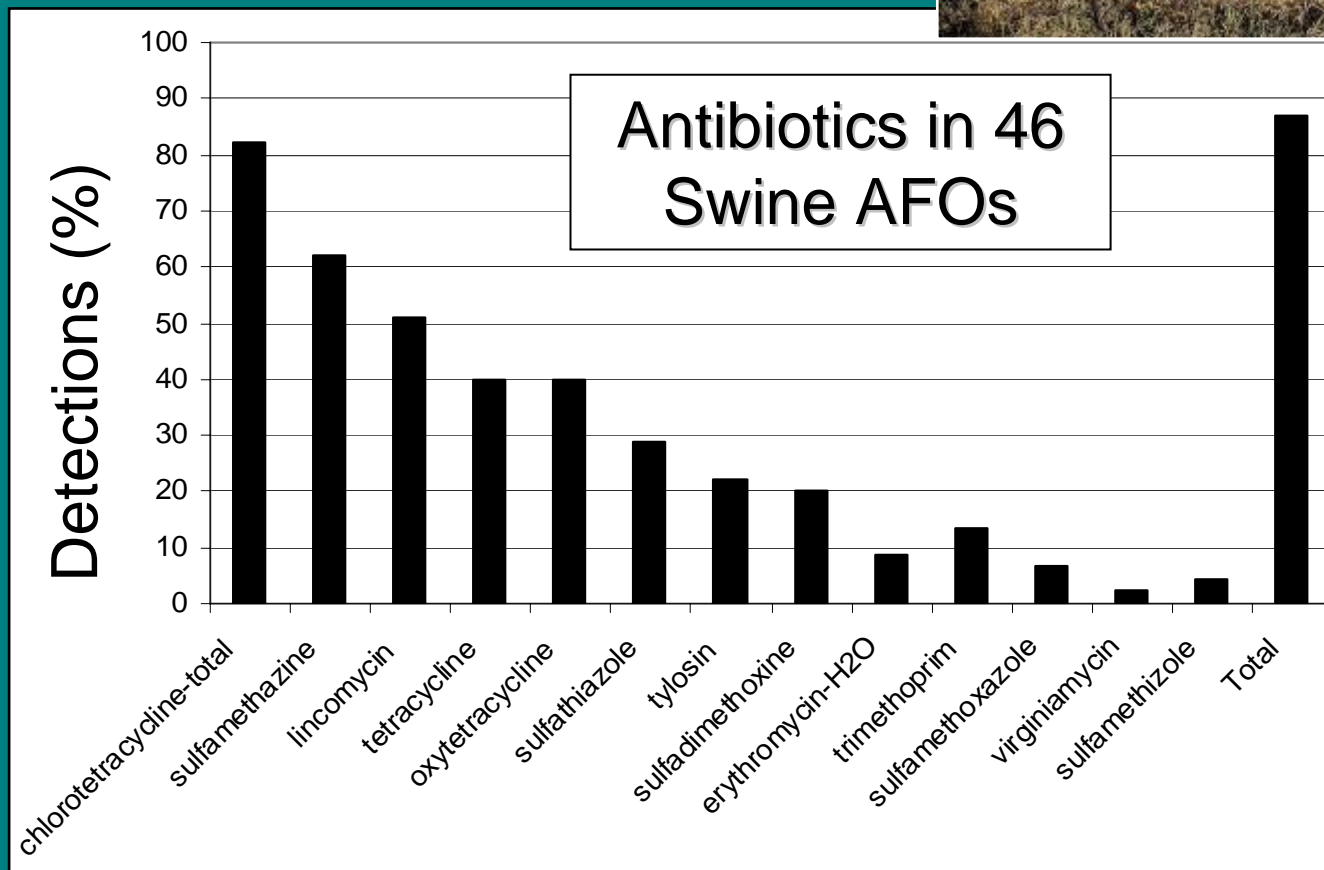
## Wastewater Treatment Plants

### Boulder Creek, CO



# *Sensitive Env'l Settings?*

## Animal Feeding Operations



# *Sensitive Env'l Settings?*

Soils amended with  
biosolids and manures



## Biosolids from 9 locations across the US

### Concentration ( $\mu\text{g}/\text{kg}$ )

	<u>Range</u>	<u>Median</u>
Carbamazepine	15-1,200	68
Diphenhydramine	32-22,000	340
Fluoxetine	100-4,700	370
Triclosan	1,170-32,900	10,200

# *Sensitive Env'l Settings?*

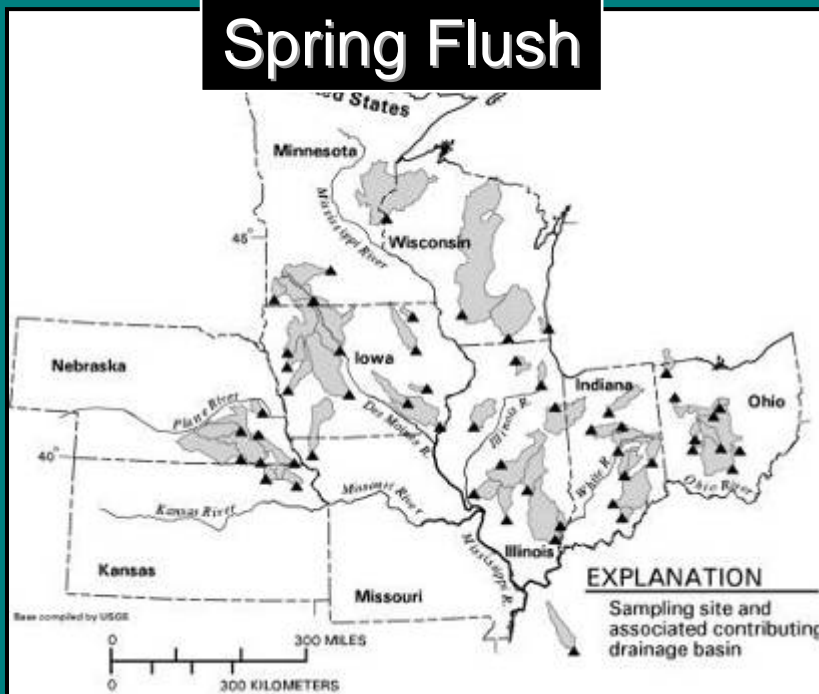
## Hydrologic Events



Cedar Rapids, IA

**Midwest Floods, Spring '08**

### Spring Flush



21 herbicides, 27 degradates,  
36 antibiotics in 51 Midwest  
 Streams

# *Adverse Eco Health Effects?*

## Endocrine Disruption

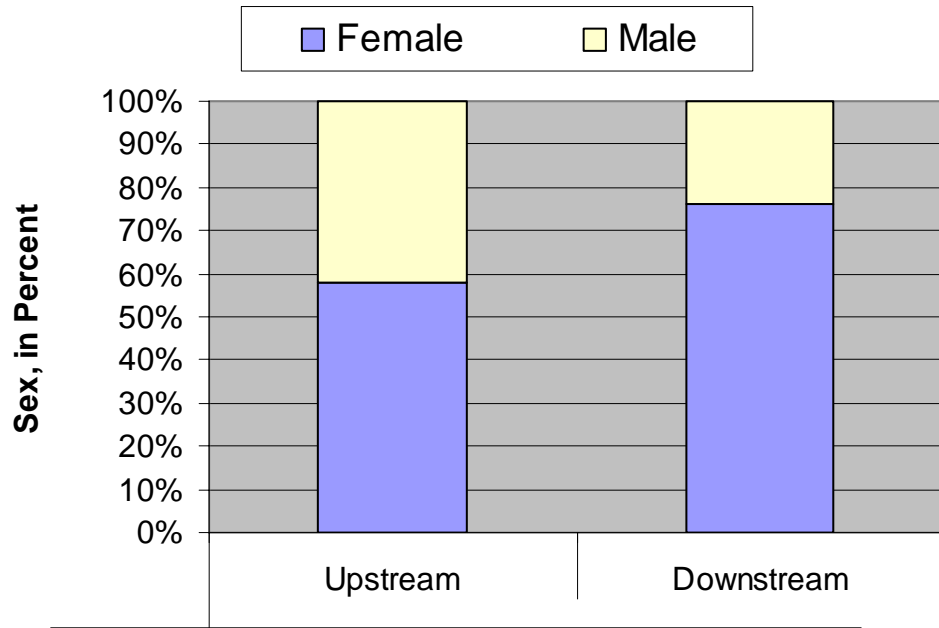


We conducted a 7-year, whole lake experiment at the (ELA) in Ontario, Canada, and showed that chronic exposure of fathead minnow to low concentrations (5–6 ng/L) of 17-ethynylestradiol led to feminization of males through the production of vitellogenin mRNA and protein, impacts on gonadal development as evidenced by intersex in males and altered oogenesis in females, and, ultimately, a near extinction of this species from the lake.

# Adverse Eco Health Effects?

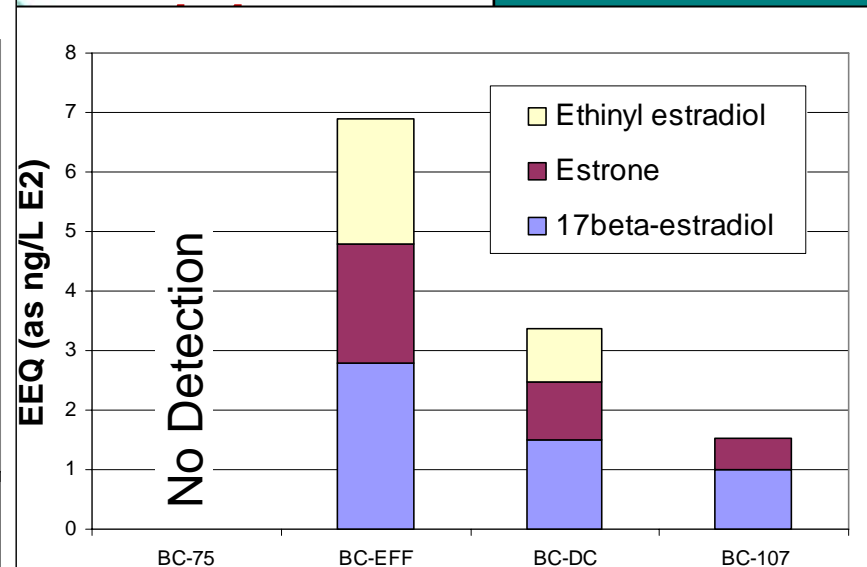
## Endocrine Disruption

### Boulder Creek, CO



**Intersex 0%**

**19%**

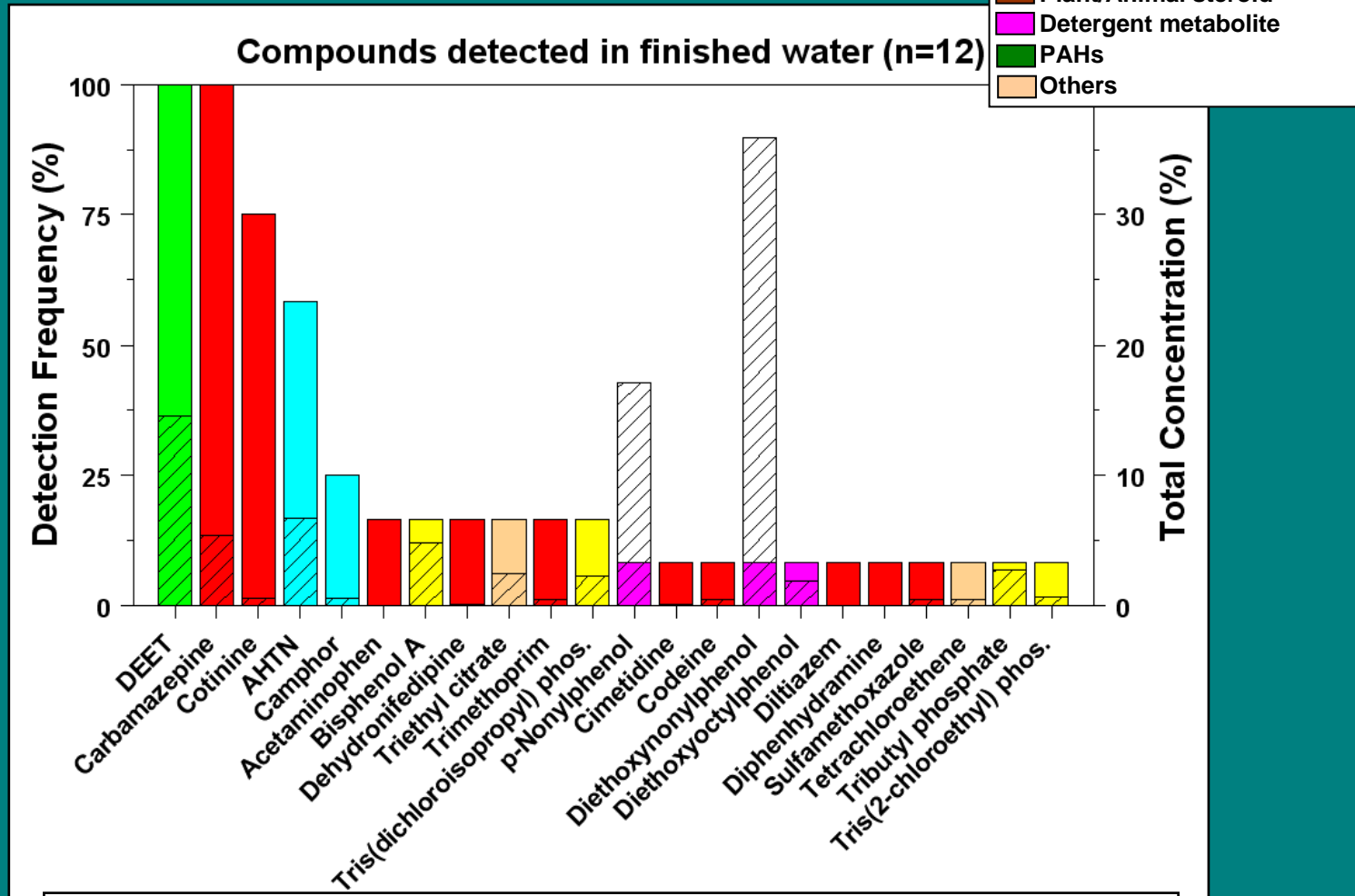


**am water, in ng/L**

# Other Ecological Effects

- **Diclofenac (non-steroidal anti-inflammatory):** Consumption of diclofenac-treated meat caused renal failure in *vultures* (Oaks et al., 2004).
- **Antibiotics:** Reduced soil microbial activity at env. concentrations (Costanzo et al., 2005; Thiele-Bruhn and Beck, 2005).
- **Ciprofloxacin, triclosan, Tergitol NP 10:** shifts in algal community structure (Wilson et al., 2003) .
- **Drug Mixtures 13:** Inhibited growth of human embryonic cells at env. levels (Pomati et al., 2006).

# DW & human health risk?



Drinking-Water Treatment, NJ

# *Human health risk?*

## Antibiotic Resistance

- Resistance develops in organisms.
- Environmental transfer of resistance genes.
- Multiple resistance.
- Resistance from non antibiotics.
- Resistance from chronic low-level exposure?

Direct use in orchards.

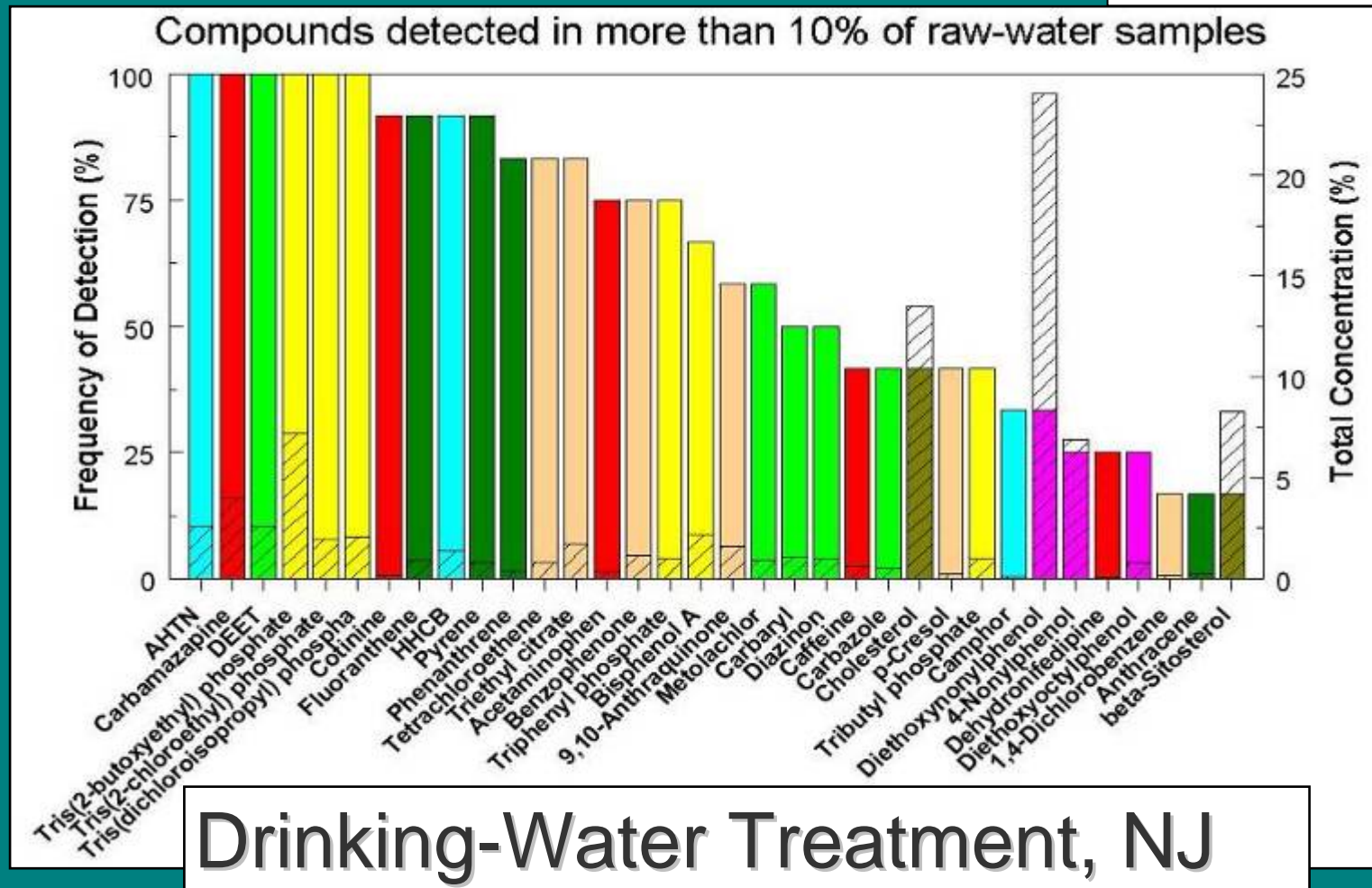
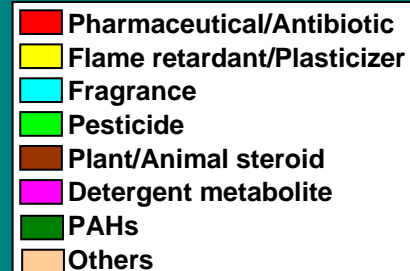


Aquaculture



Animal waste lagoons

# Reduce entry or remove?



# Importance of prioritizing chemicals?

- Potential to Enter the Environment.
  - ✓ Quantities used.
  - ✓ Anticipated environmental behavior.
  - ✓ Pathways for chemical release.
- Health significance (Accessing avail. info).
  - ✓ Using all available information
  - ✓ Mode of Action (mixtures)
- Ability to measure - **Reliably**.
- Potential as chemical indicators/tracers.

# Interagency Pharmaceuticals in the Environment Work Group

- Chartered May, 2006 under the Toxics and Risk Subcommittee, Committee on the Environment and Natural Resources (CENR)
  
- Developing a research strategy that :
  - Defines our current understanding,
  - Defines & prioritizes research needs, and
  - Describes a plan for federal collaboration to address those needs.

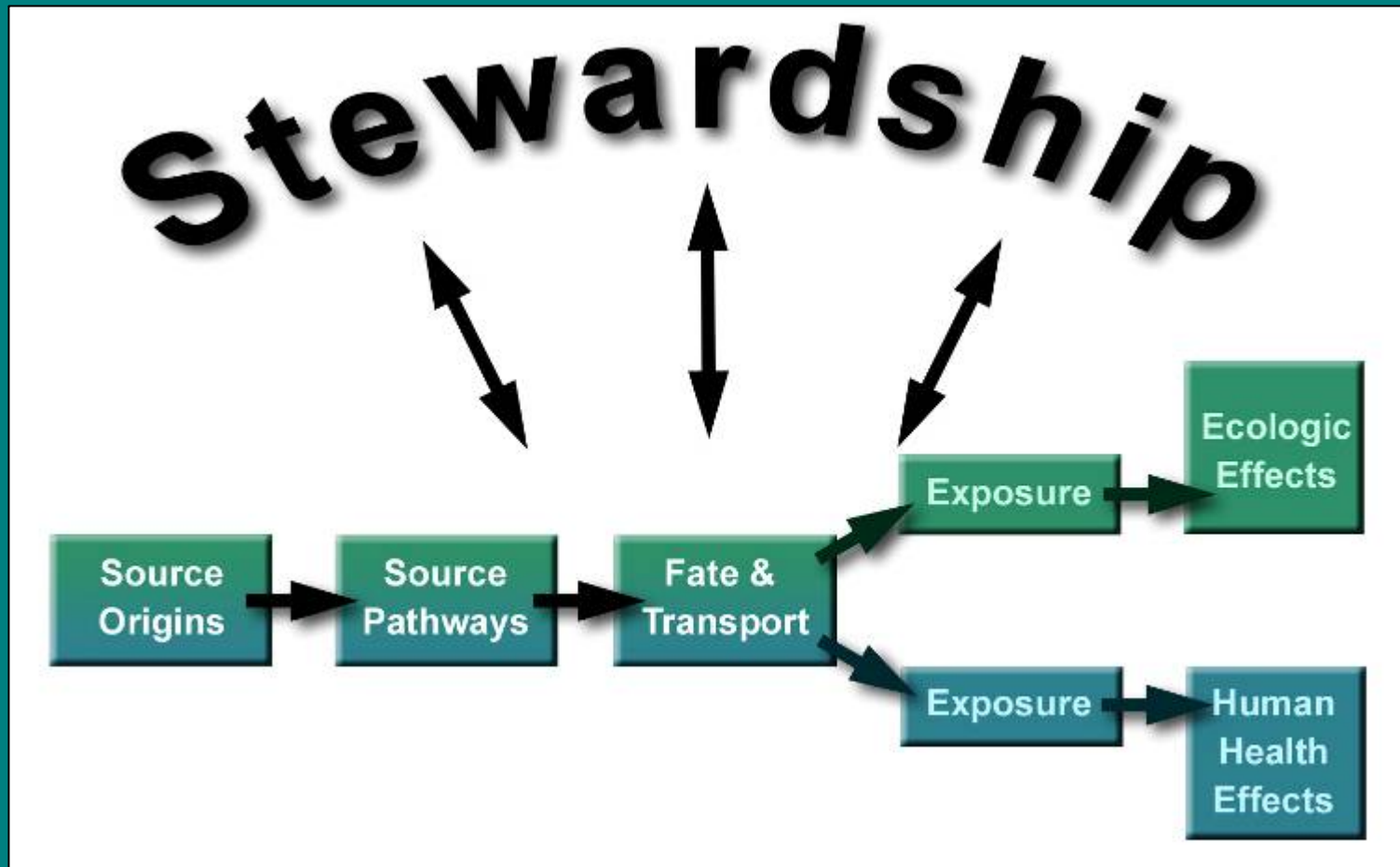
# Participating Agencies

- EPA\*
- FDA\*
- USGS\*
- FWS
- CDC
- NIEHS
- USDA
- NOAA

## Co-Chairs:

- H. Zenick, EPA,
- S. Fitzpatrick, FDA,
- H. Buxton, USGS

# Science to Guide Research and Inform Stewardship



Thank you!

*<http://toxics.usgs.gov>*