Contaminants of Emerging Concern and Arid West Water Resources

Shane Snyder, Ph.D.

Professor & Co-Director

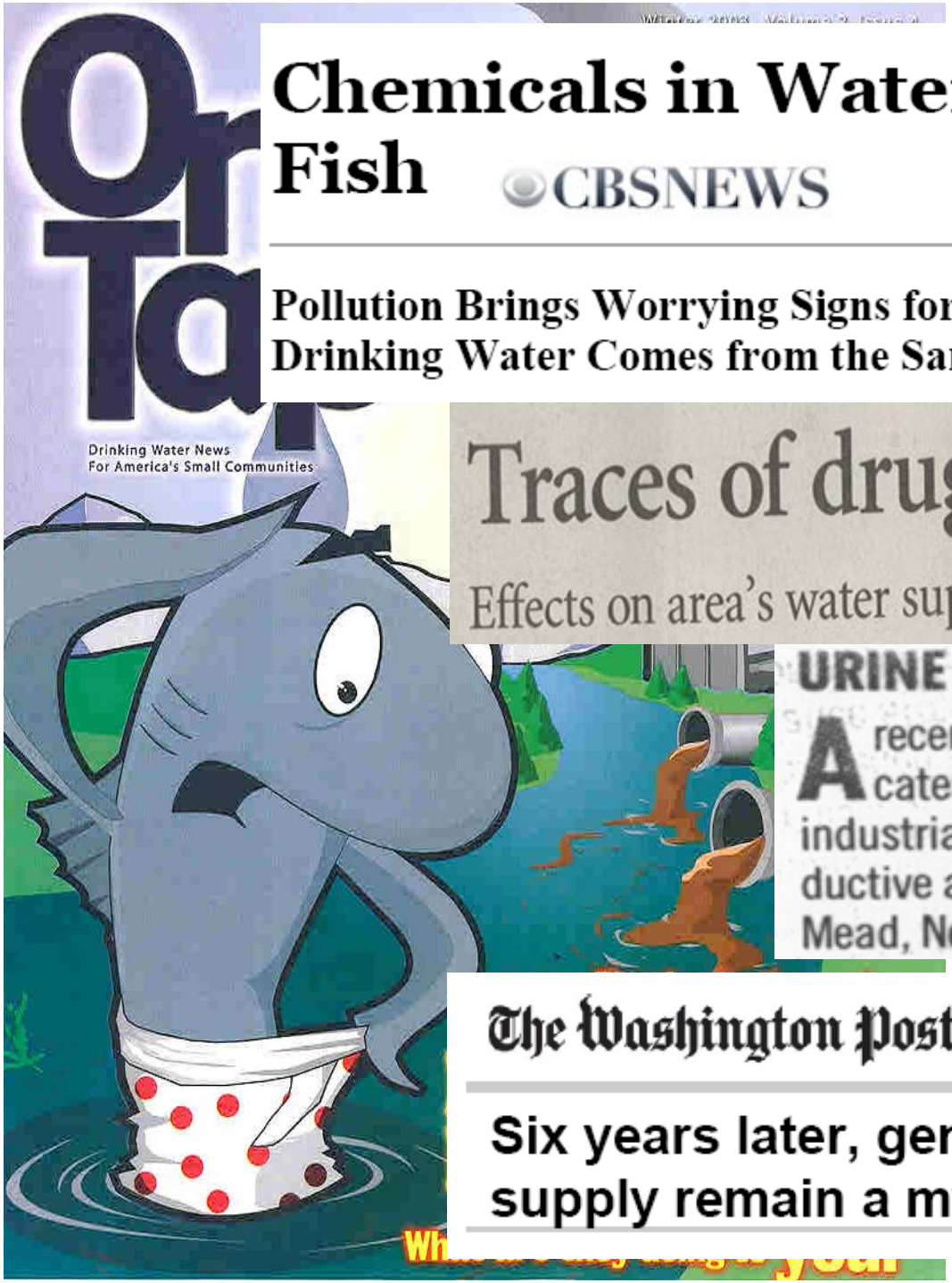
Chem. & Environ. Engineering

University of Arizona

azengineering

ALEC

Arizona Laboratory for Emerging Contaminants



Chemicals in Water Alter Gender of Fish

CBSNEWS

Pollution Brings Worrying Signs for Fish Populations; Worse, Most U.S. Drinking Water Comes from the Same Sources

Traces of drugs found in LV Wash

Effects on area's water supply unknown

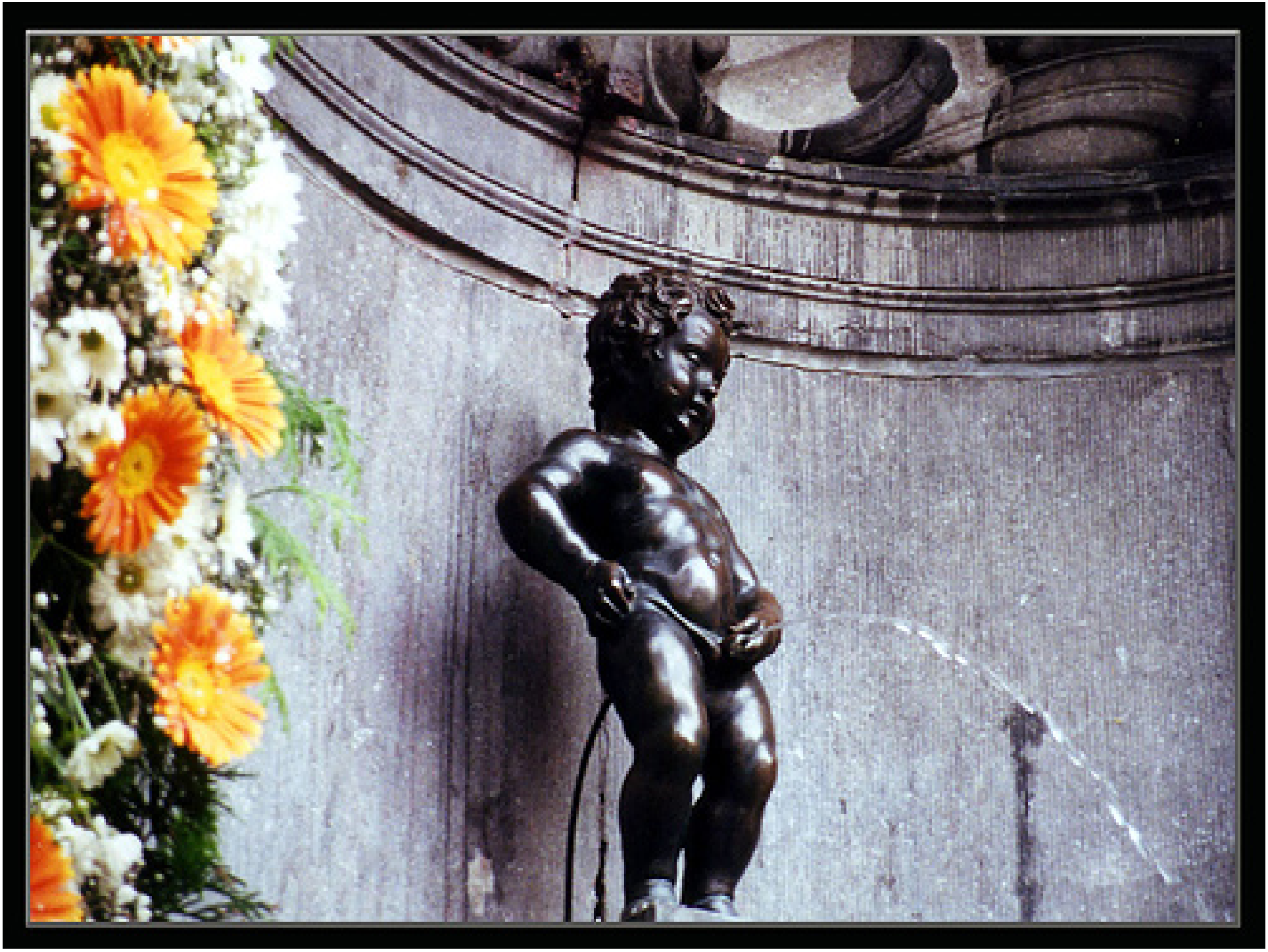
only suspected, lindane — has been confirmed.

URINE FOR A SURPRISE

A recent Michigan State University study indicates that hormone-laden human urine, not industrial chemicals, could be triggering reproductive abnormalities in male fish near Lake Mead, Nevada. Researchers testing the waters of

The Washington Post

Six years later, gender-bending fish in our water supply remain a mystery



knoxnews.com
Printer-friendly story
Read more at knoxnews.com

'Pee lab' flushed in Anderson County

By News Sentinel staff

Originally published 08:39 a.m., April 3, 2009
Updated 08:39 a.m., April 3, 2009

CLINTON - The Anderson County Sheriff's Department has busted a so-called "pee lab," seizing 144 gallons of urine and assorted methamphetamine-making components.

Investigators, acting on an anonymous tip, found 241 two-liter bottles and 17 one-gallon jugs of urine at 473 Carroll Hollow Rd. about 2 p.m. Thursday, according to Chief Deputy Mark Lucas.

They charged Rickie Jack Harber, 47, with promotion of methamphetamine manufacture. His bond was set at $20,000.

The sources of the urine were not immediately identified.

The urine-extraction lab is the third but largest found in Anderson County, Lucas said in a press release.

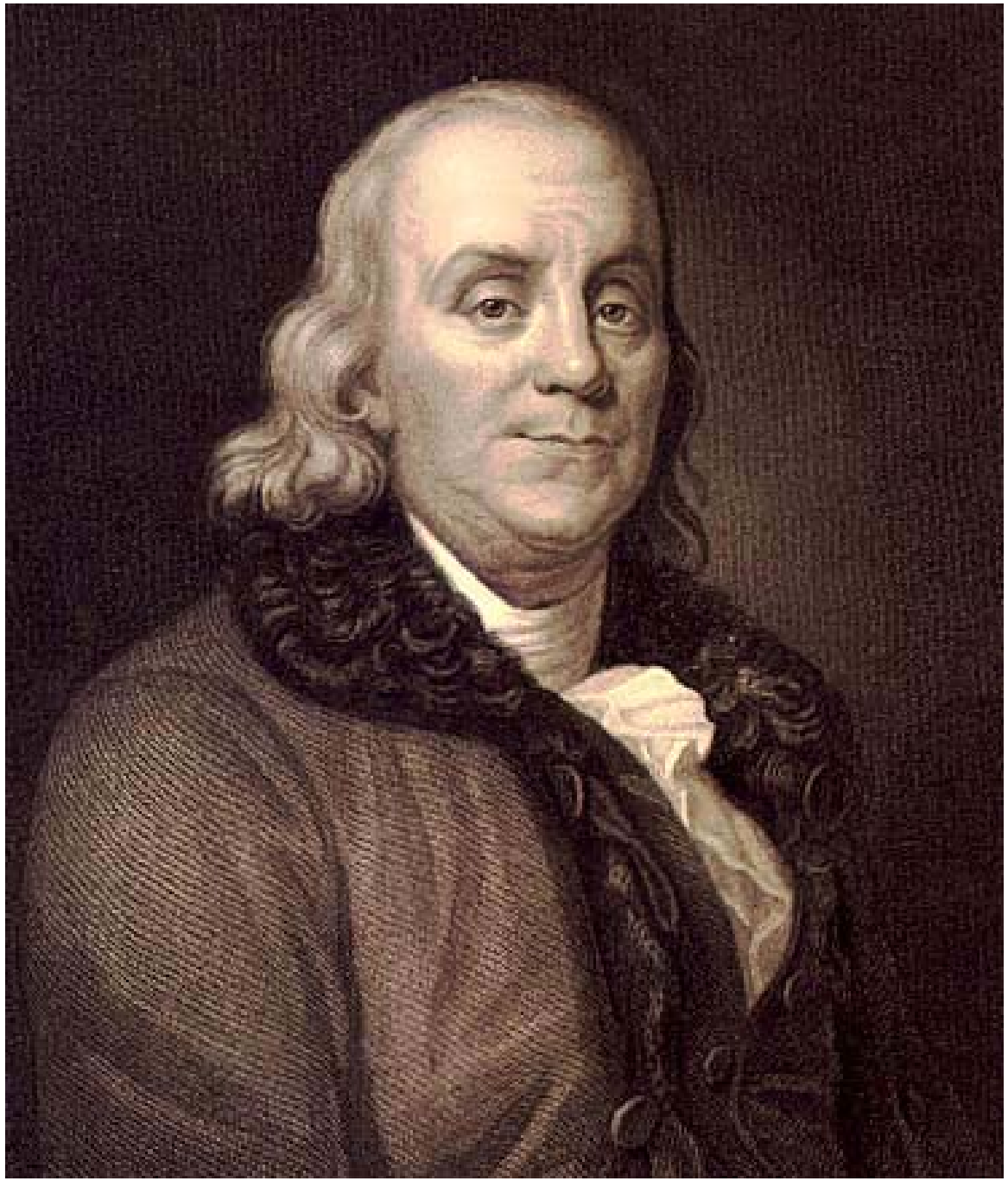

TOILET TO YOUR TAP!
Why are Sacramento & Stockton allowed to Dump their Sewage into the Delta/Aquaduct Water?
THE WATER SOURCE FOR 20 MILLION PEOPLE DOWNSTREAM!

Three Key Points

I. Trace contaminants are ubiquitous in water

II. Ecological impacts demonstrated, human unlikely

III. Public perception and trust are critical for water reuse



"We know the value of water when the well runs dry."

Benjamin Franklin

Poor Richard's Almanac - 1732

"I am convinced that, under present conditions and with the way water is being managed, we will run out of water long before we run out of fuel."

Peter Brabeck-Letmathe

Chairman of Nestlé
The Economist – November 2008

TIME
IN PARTNERSHIP WITH CNN

Thursday, Dec. 04, 2008

Dying for A Drink

By Bryan Walsh

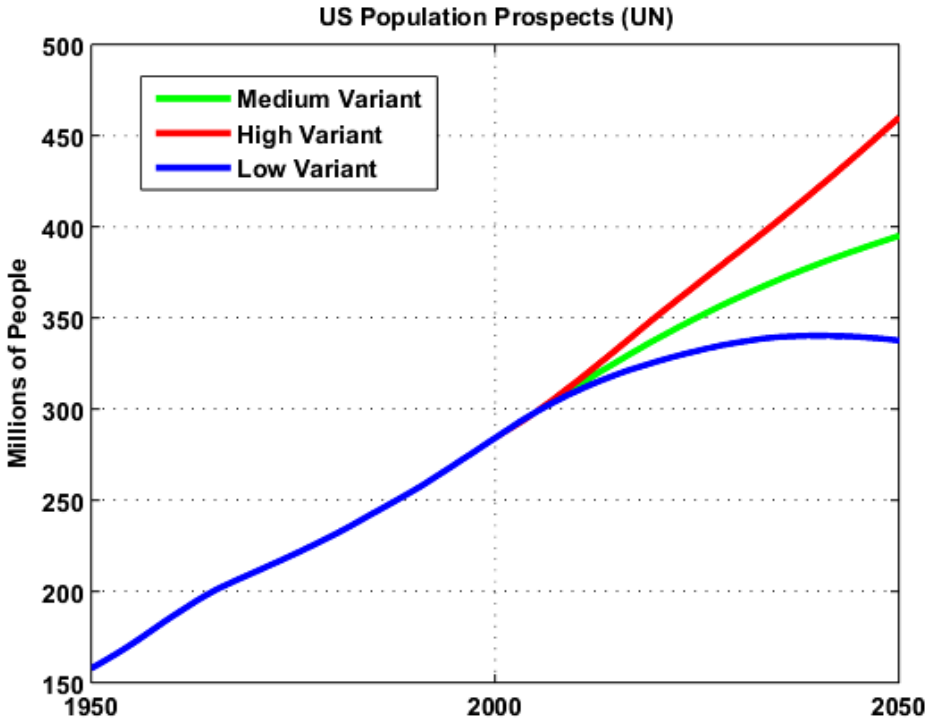

Fishing Dock at Lake Mead


Lake Lanier - Georgia


Lake Wivenhoe – Australia

U.S. Population Could Exceed 400,000,000 by 2050

=Approximately 2.5M people/year for the next 40 years
=Approximately the population of Houston TX each year



Water Supplies Are Vulnerable

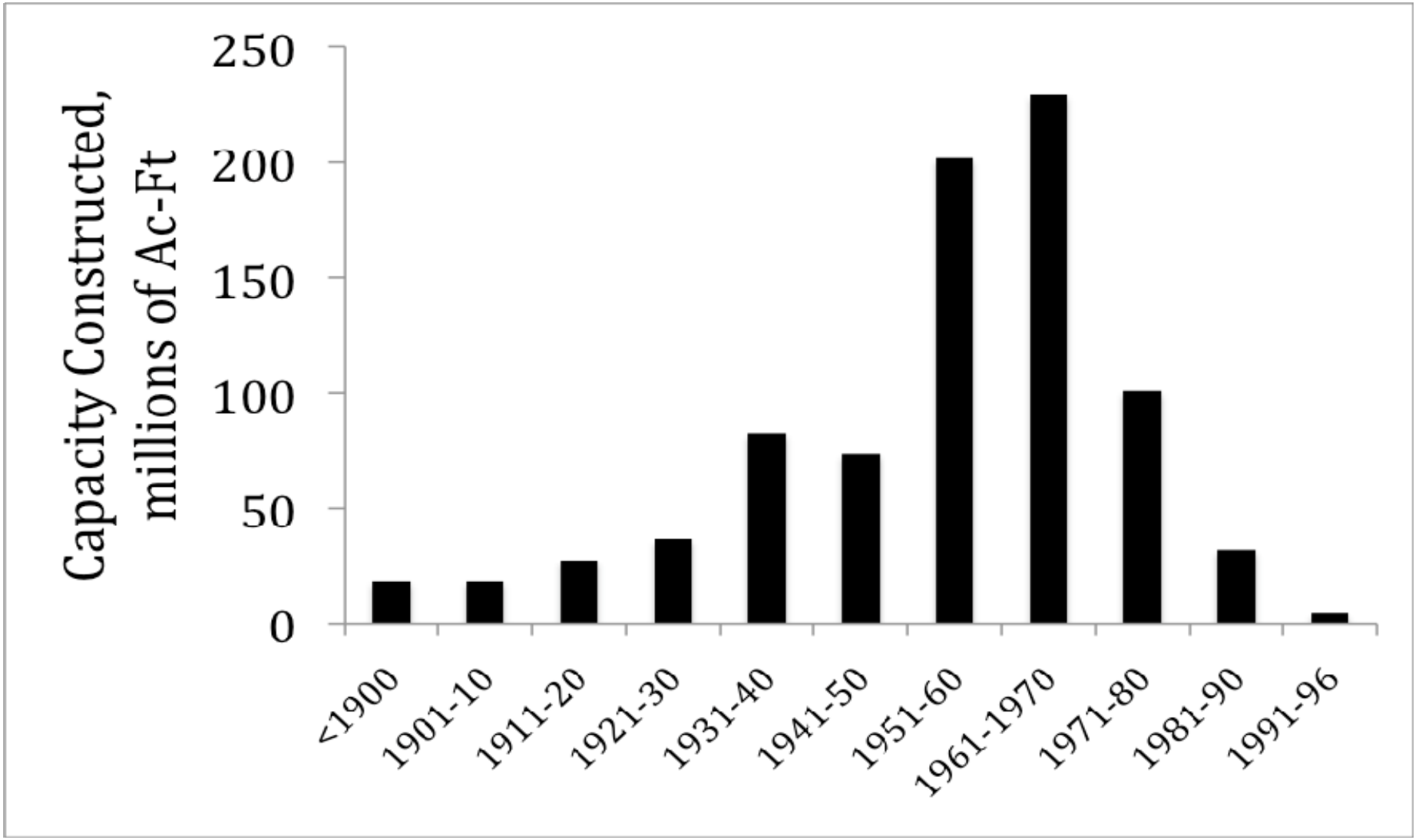
Population Growth is 20% to 50% in Most Water-Stressed Areas

Source: DOE/NETL (M. Chan, July 2002)

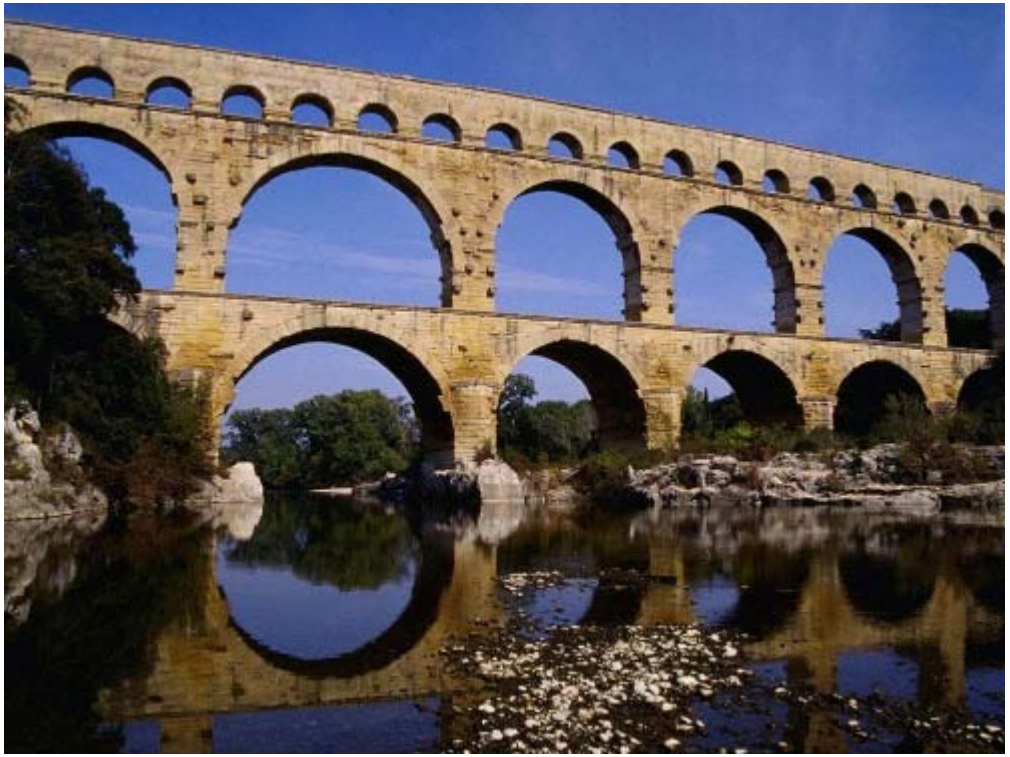
EAO Energy Analysis Office
Understanding Energy Issues

NREL National Renewable Energy Laboratory

Low Growth in Water Storage



Adapted from Graf, 1999



The New York Times
nytimes.com

August 10, 2008

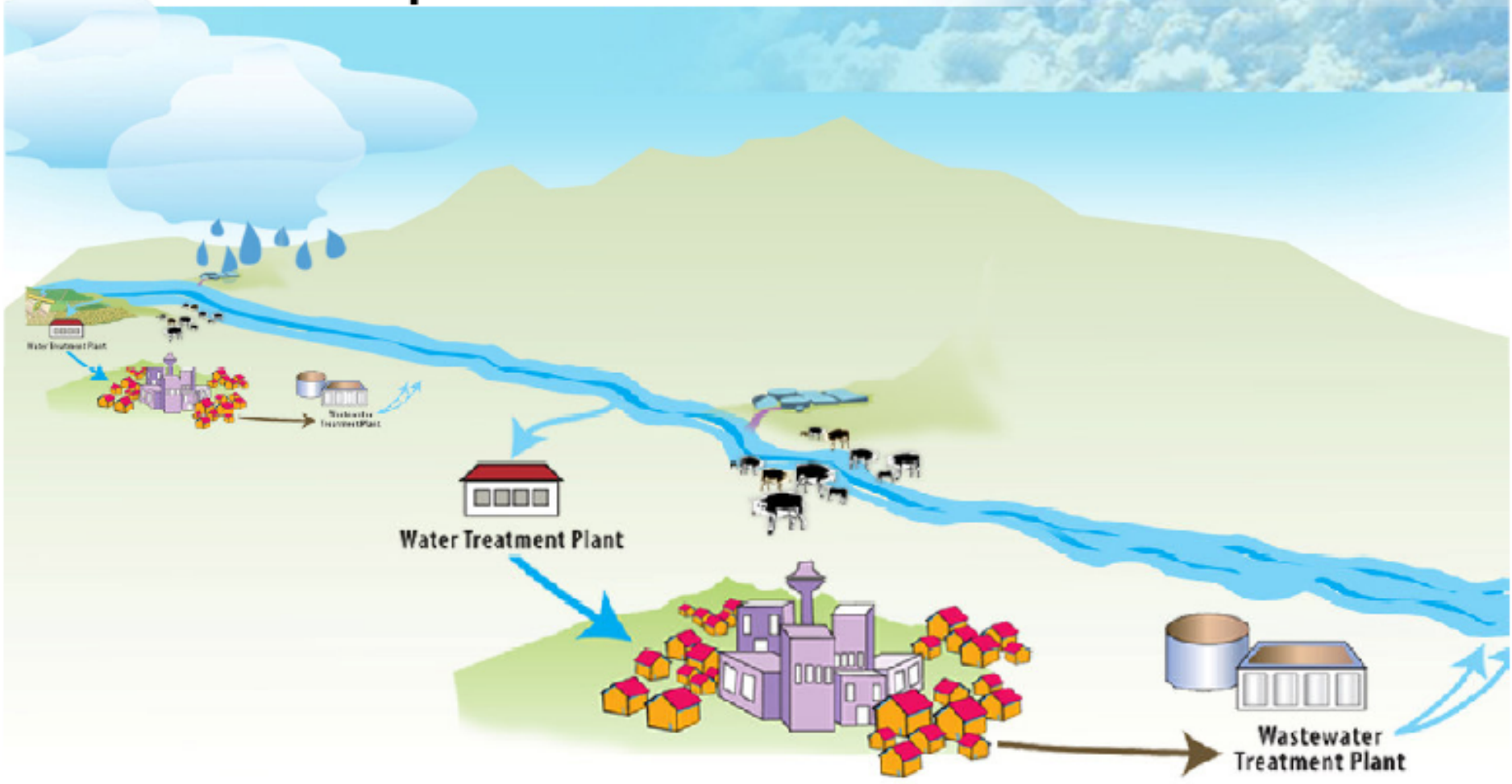
A Tall, Cool Drink of ... Sewage?

By ELIZABETH ROYTE

All water on earth is recycled: the same drops that misted Devonian ferns and dripped from the fur of woolly mammoths are watering us today. From evaporation to condensation and

De Facto or Unplanned Reuse

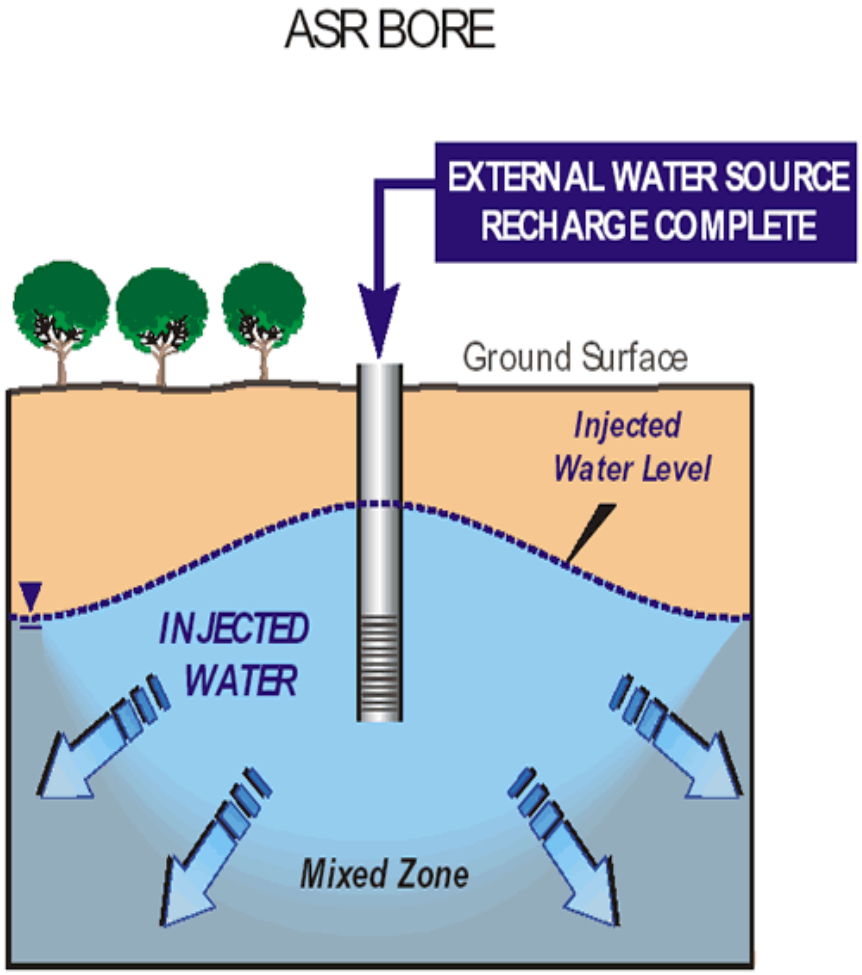
another city and another wastewater treatment plant



Reuse Is a Reality for a Large Portion of the Population *Right Now*


Trinity River, Texas
0
100
km
Gainesville
Denton
McKinney
Rockwall
Dallas
Fort Worth
Waxahachie
Palestine
Lake Livingston
Austin
Houston
Liberty
N

Many US Cities Already Reuse Water for Potable Supplies



Higher water level and greatly improved groundwater salinity

Facing the Yuck Factor

FEATURE ARTICLE - September 17, 2007 *by Peter Friederici*

Facing the yuck factor. PAUL LACHINE

How has the West embraced water recycling? Very (gulp) cautiously

Source: http://www.hcn.org/issues/354/17227

"Analytical Arms Race"

GC-FID
Sensitivity: ppm
Selectivity: Ret Time

GC MSD
Sensitivity: ppb
Selectivity: Ret Time
unit resolution, SIM

LC-MS/MS
Sensitivity: ppt
Selectivity: Ret Time
unit resolution, MRM

FTMS
Sensitivity: ppb-ppt
Selectivity: Ret Time
accurate mass, MRM

Snyder et al., 1999. Environmental Science & Technology, pgs. 2814-2829

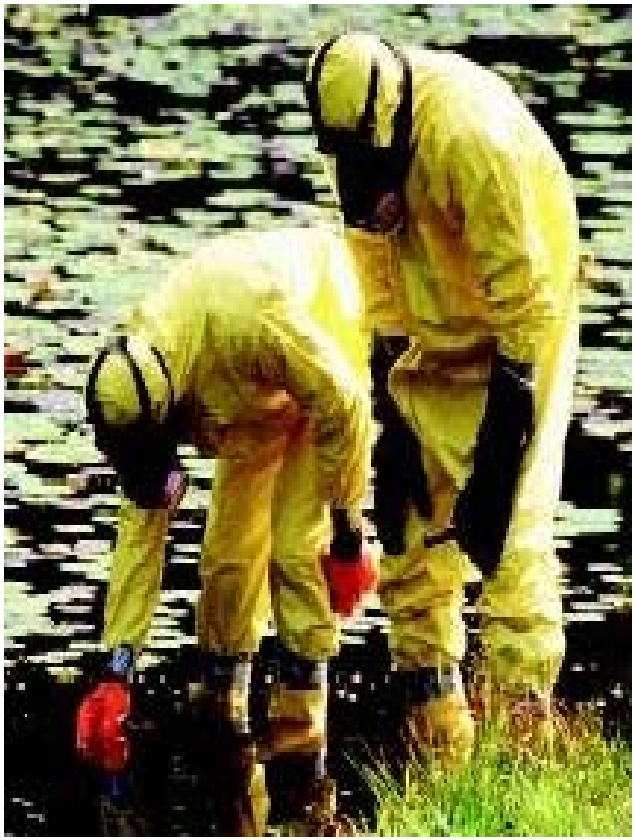
Talanta 79 (2009) 1425–1432

On-line solid phase extraction LC–MS/MS analysis of pharmaceutical indicators in water: A green alternative to conventional methods

Rebecca A. Trenholm*, Brett J. Vanderford, Shane A. Snyder

Water Quality Research and Development Department, Southern Nevada Water Authority, 1350 Richard Bunker Road, Henderson, NV 89015, USA

USGS
science for a changing world



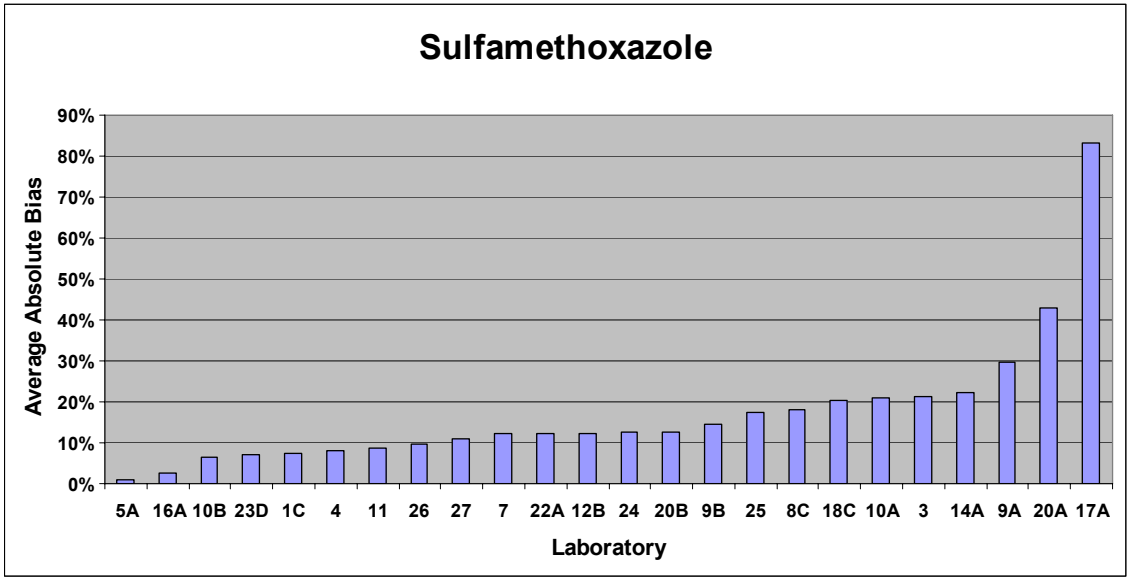
- **Prevent sample contamination:**
  - On the day of sampling activities, avoid contact with or consumption of the products listed below. Where contact with or consumption of these products is unavoidable, the collection of field blanks is strongly recommended.
    - Prescription drugs, medications, and hormonal substances
    - Soaps and detergents, including antibacterial cleansers
    - DEET (active ingredient in most insect repellents)
    - Fragrances (cologne, aftershave, perfume)
    - Sunscreen
    - Animal or human urine or excrement
    - Caffeine (coffee, tea, colas)
  - Avoid breathing directly over open samples/equipment.
  - Avoid direct contact between yourself (including clothing) and the sample, sampling device, and processing equipment. Clothing is a source of detergents, fragrances, and fire retardants.

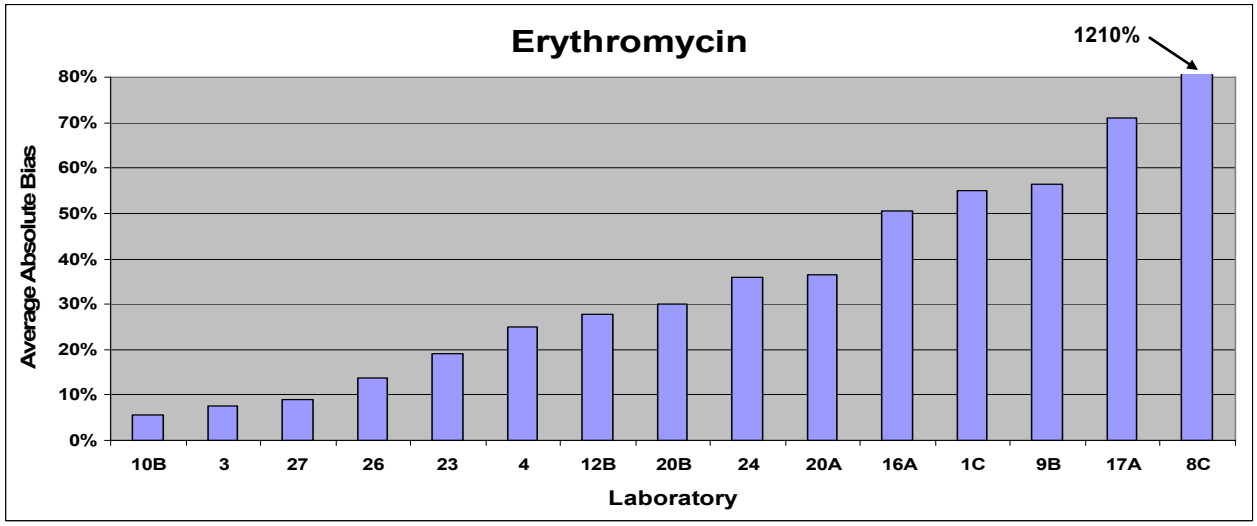
Interlaboratory Comparison (WaterRF 4167)
22 compounds & 24 labs

Target Compounds	Number of Laboratories	Target Compounds	Number of Laboratories
Carbamazepine	24	Diclofenac	16
Ibuprofen	23	17β-Estradiol	16
Caffeine	22	Estrone	16
Sulfamethoxazole	21	Fluoxetine	15
Gemfibrozil	20	Ciprofloxacin	13
Triclosan	20	Progesterone	12
17α-Ethynylestradiol	18	Testosterone	12
Trimethoprim	18	Erythromycin	11
Naproxen	17	4-nonylphenol	11
Acetaminophen	16	Primidone	11
Bisphenol A	16	4-*tert*-octylphenol	10

Interlaboratory comparison (DI water)

Good

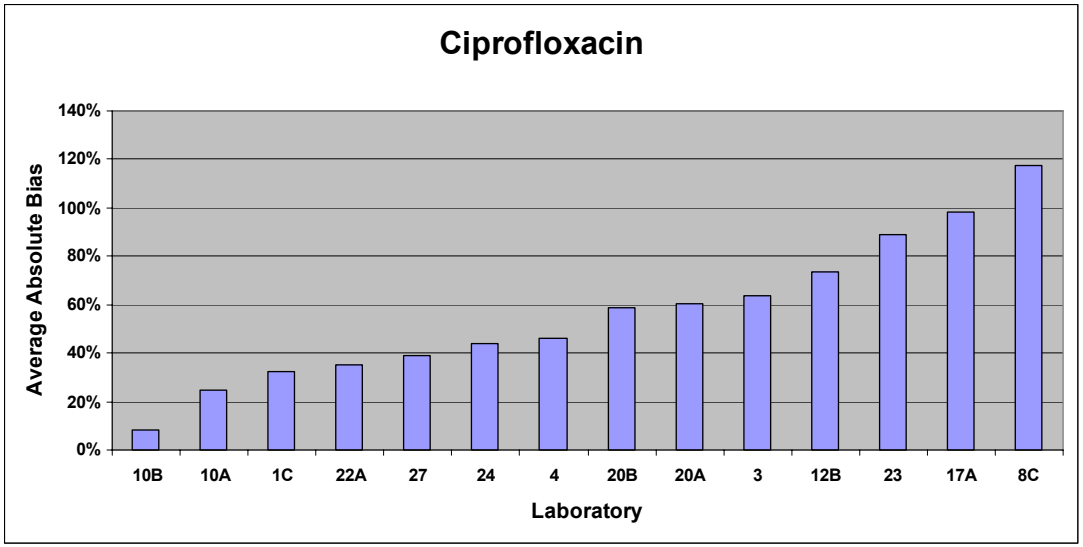


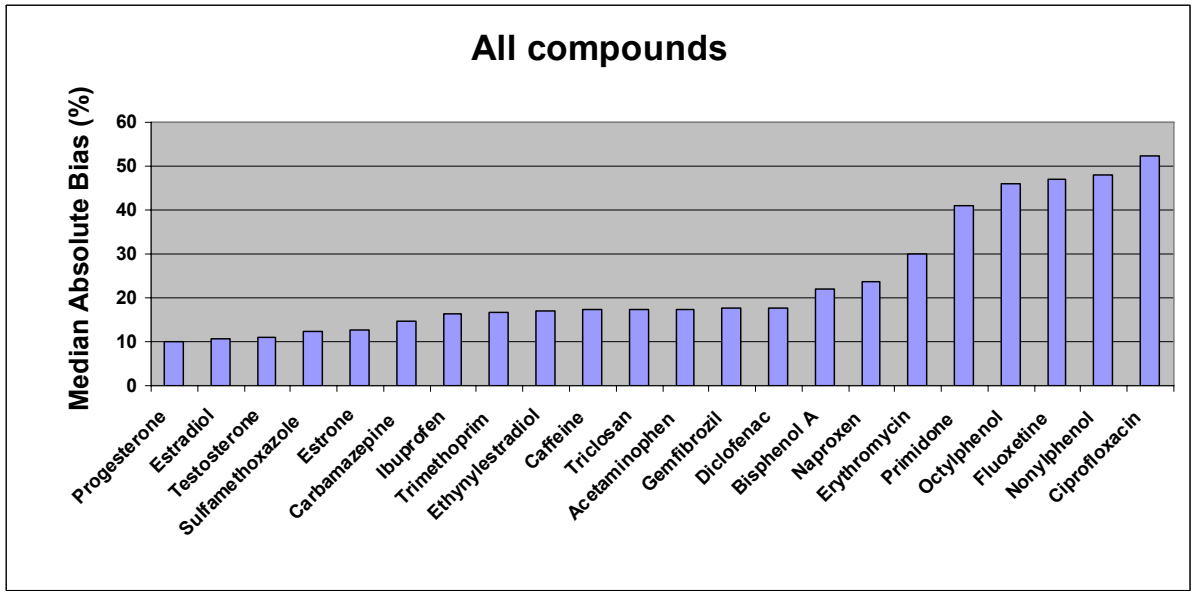


Bad

Interlaboratory comparison (DI water)

Ugly





All

Three Key Points

I. Trace contaminants are ubiquitous in water

II. Ecological impacts demonstrated, human unlikely

III. Public perception and trust are critical for water reuse

Hudson River Anglers in the 1940s

Noticed that fish caught below a pharmaceutical plant were far larger than other parts of the river.

Fish had been exposed to significant concentrations of tetracycline.

Later experiments determine the effect was also reproducible in chickens and cows.

Antibiotics in Animal Feeds and Animal Production

Thomas H. Jukes

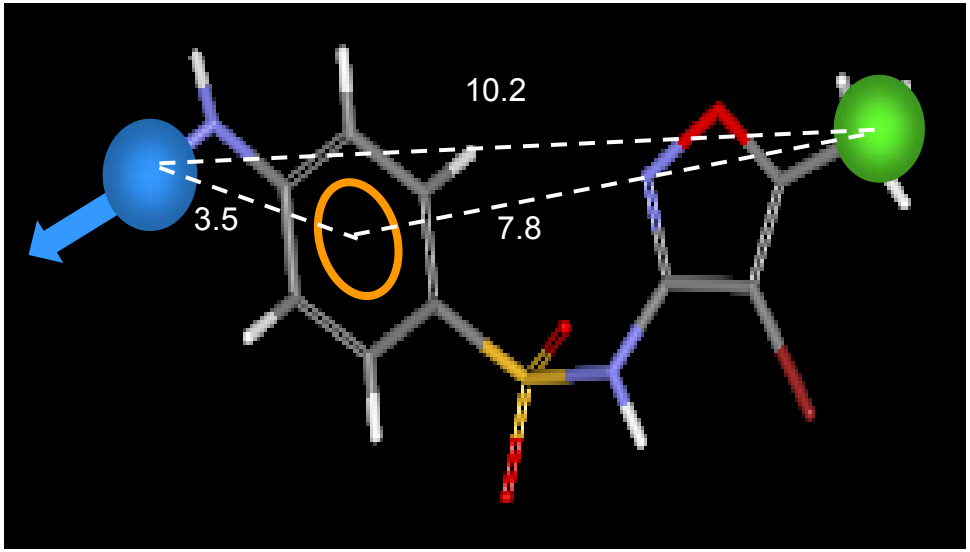
September 1972 BioScience Vol. 22 No. 9

February 22, 1946 SCIENCE

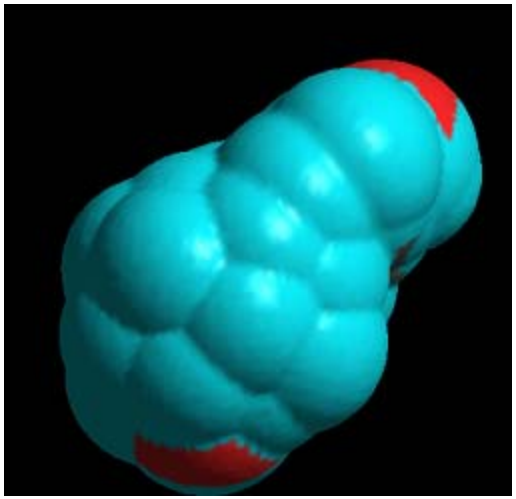
Sex Hormonal Action and Chemical Constitution

F. W. SCHUELER
University of Chicago

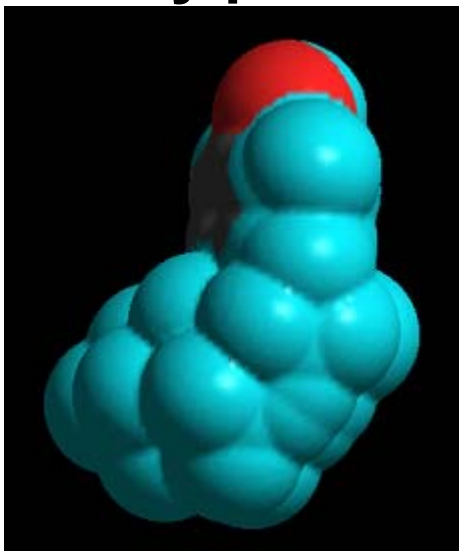
The following communication presents a new hypothesis regarding the essential chemical and structural features sufficient for male and female sex hormonal activity as evidenced by comb growth in the



Estradiol



Nonylphenol

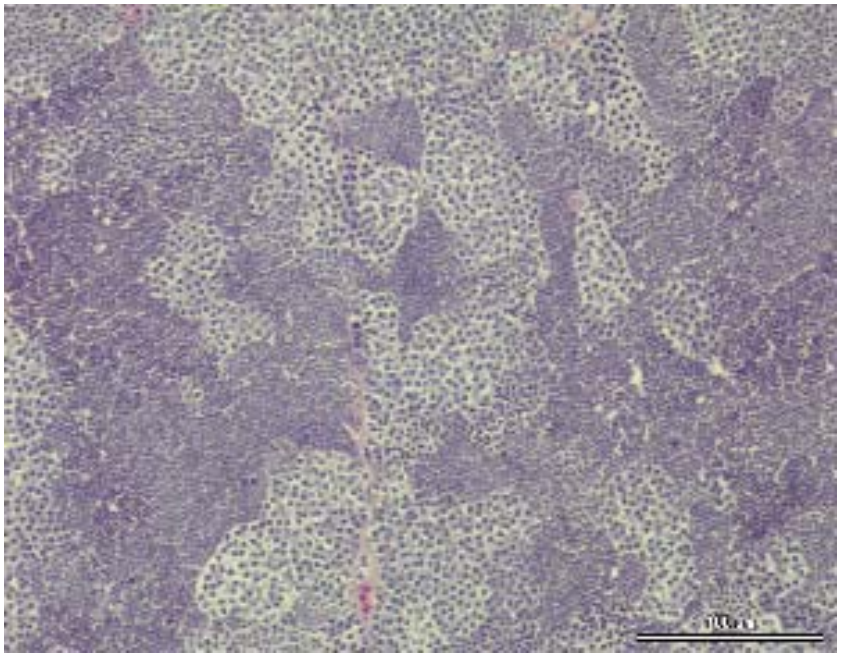


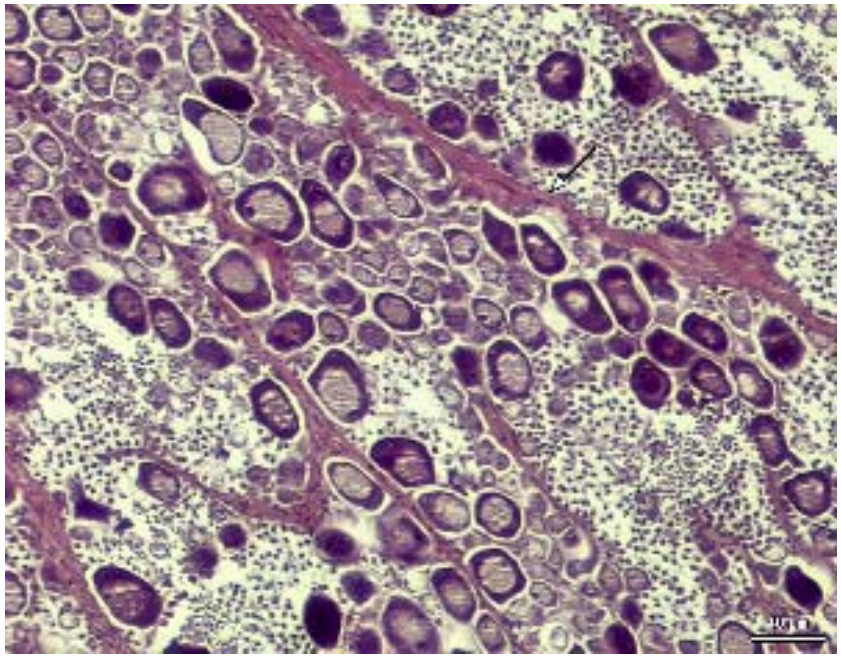
Chemistry and Ecology, 1994, Vol. 8, pp. 275–285

ESTROGENIC EFFECTS OF EFFLUENTS FROM SEWAGE TREATMENT WORKS

C.E. PURDOM,[1] P.A. HARDIMAN,[1] V.J. BYE,[1] N.C. ENO[1],
C.R. TYLER[2] and J.P. SUMPTER[2]

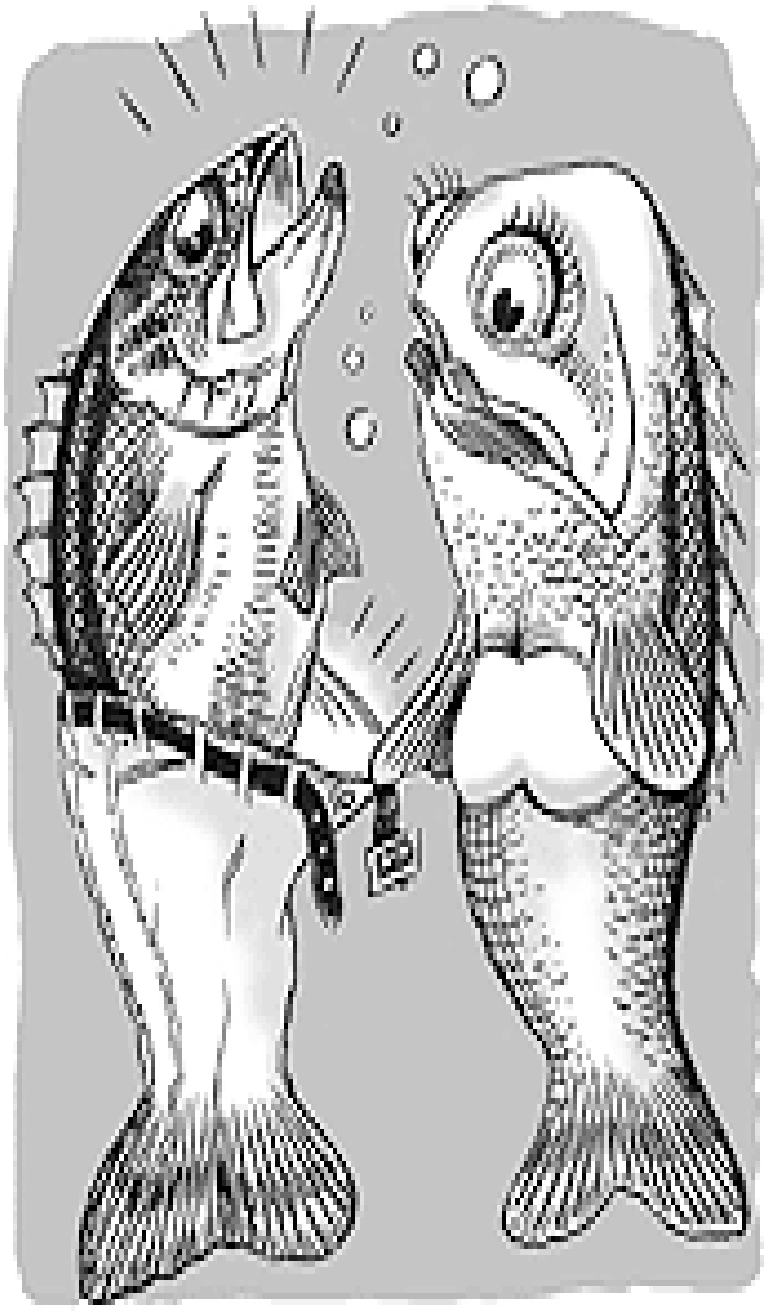
[1]*Ministry of Agriculture, Fisheries and Food, Fisheries Laboratory, Lowestoft NR33 0HT;* [2]*Department of Biology and Biochemistry, Brunel University, Uxbridge UB8 3PH*

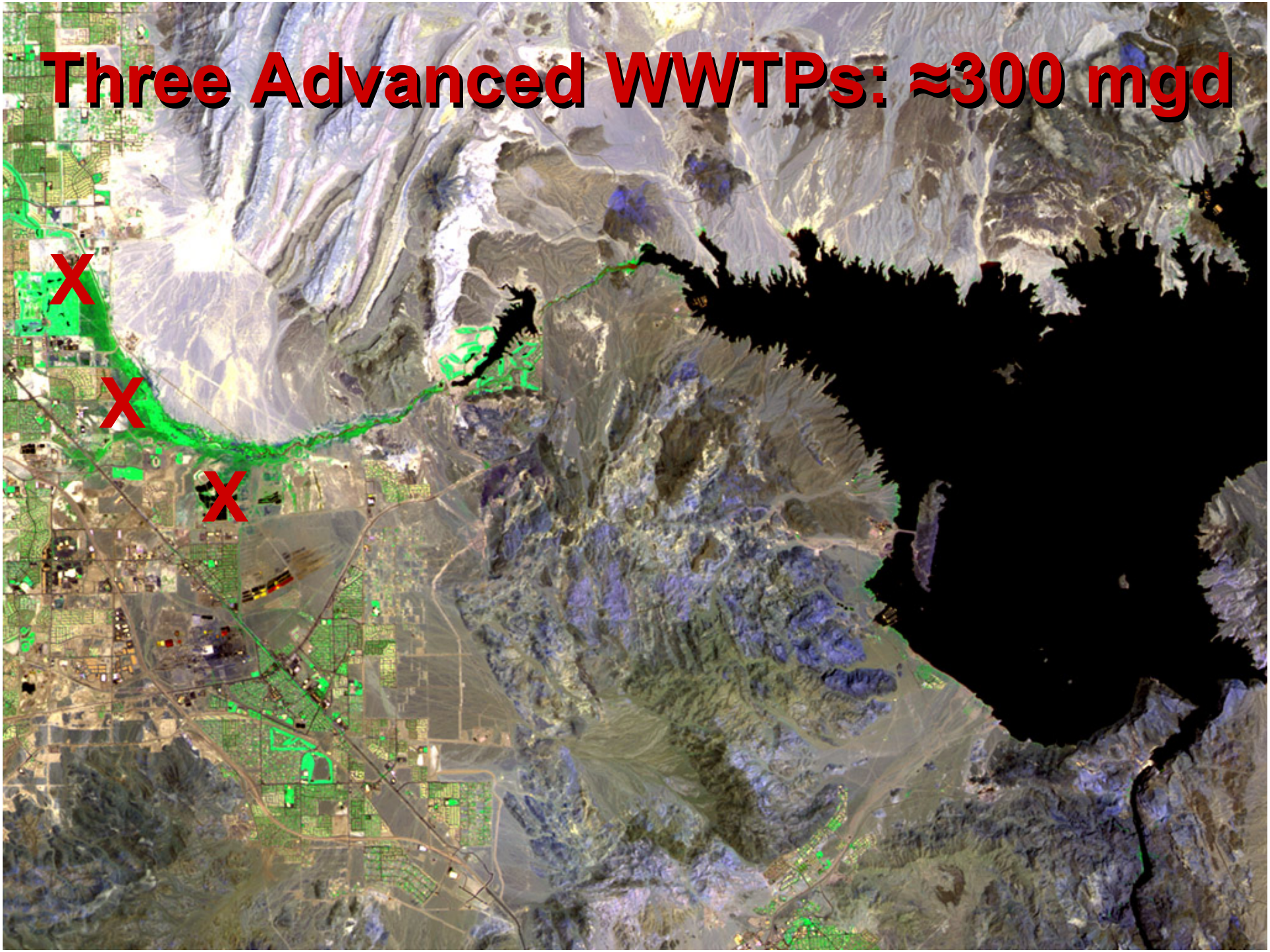


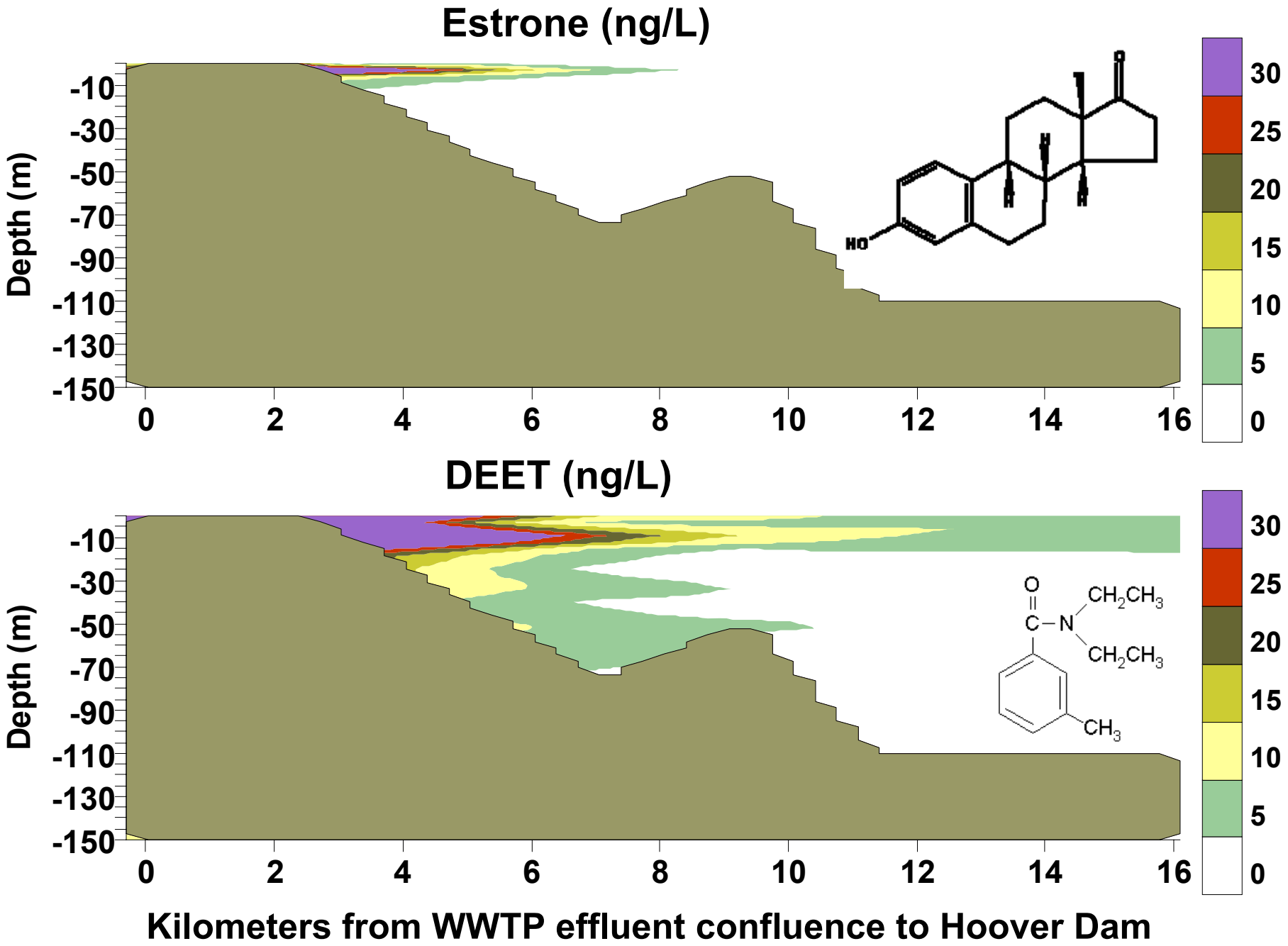


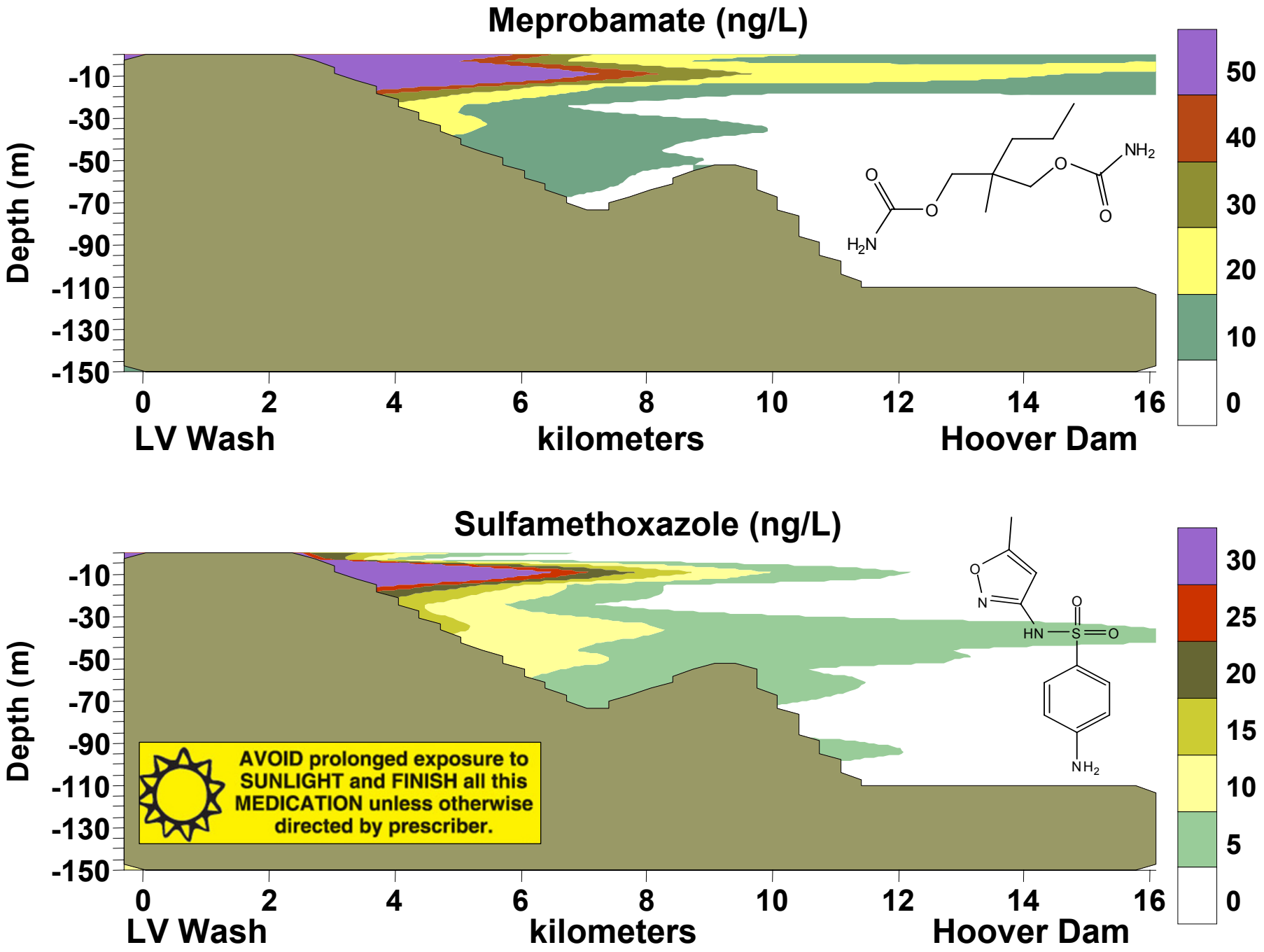
Testicles Shrinking in Las Vegas Bay

The U.S. Geological Survey, in cooperation with the U.S. Fish and Wildlife Service, recently released a four-page report, "Investigations of the Effects of Synthetic Chemicals on the Endocrine System of Common Carp in Lake Mead, Nevada and Arizona." The report summarizes a number of investigations over the last decade concerning the potential of endocrine disruption in fish in the lake. Water discharged into Lake Mead via Las Vegas Wash includes residential-irrigation runoff, stormwater runoff, subsurface flow, and tertiary treated sewage effluent, collectively carrying a

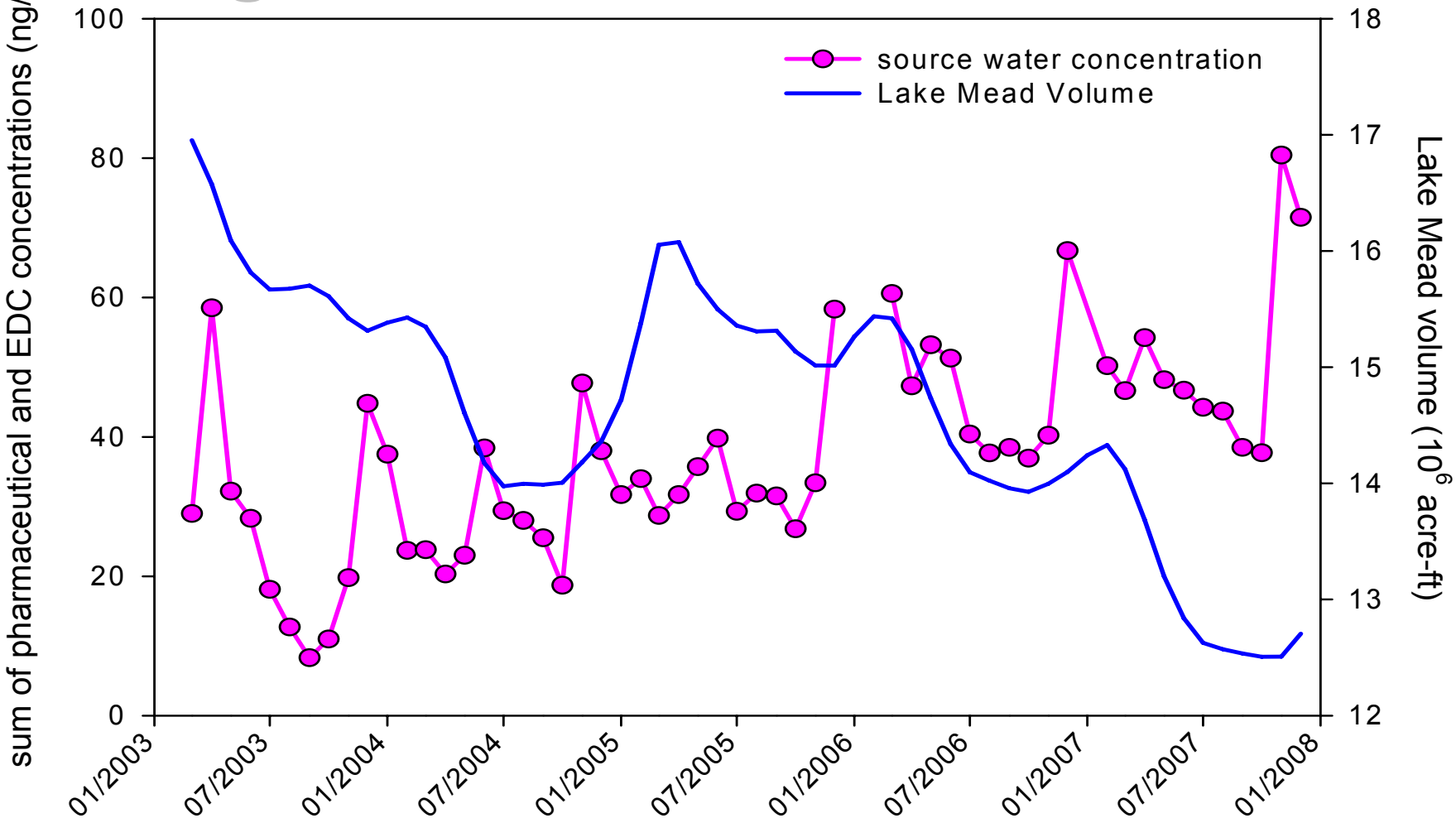



Three Advanced WWTPs: ≈300 mgd
X
X
X


Estrone (ng/L)
Depth (m)
-10
-30
-50
-70
-90
-110
-130
-150
0
2
4
6
8
10
12
14
16
HO
30
25
20
15
10
5
0
DEET (ng/L)
Depth (m)
-10
-30
-50
-70
-90
-110
-130
-150
0
2
4
6
8
10
12
14
16
O
C
N
CH2CH3
CH2CH3
CH3
30
25
20
15
10
5
0
Kilometers from WWTP effluent confluence to Hoover Dam


Meprobamate (ng/L)
Depth (m)
-10
-30
-50
-70
-90
-110
-130
-150
0
2
4
6
8
10
12
14
16
LV Wash
kilometers
Hoover Dam
50
40
30
20
10
0
NH2
O
O
O
O
H2N
Sulfamethoxazole (ng/L)
Depth (m)
-10
-30
-50
-70
-90
-110
-130
-150
0
2
4
6
8
10
12
14
16
LV Wash
kilometers
Hoover Dam
30
25
20
15
10
5
0
AVOID prolonged exposure to SUNLIGHT and FINISH all this MEDICATION unless otherwise directed by prescriber.
O
N
HN
S
O
O
NH2

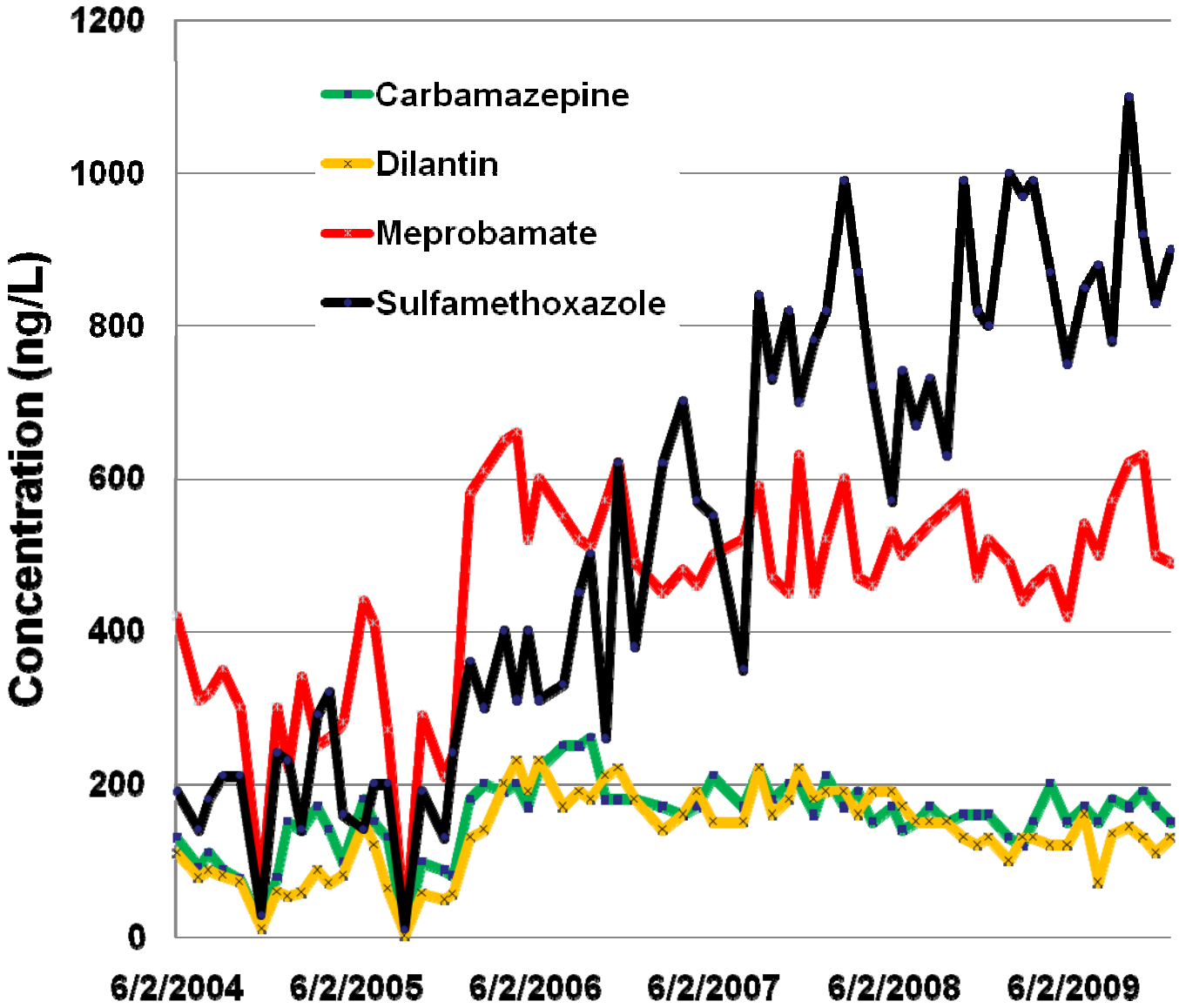
Drought: Effect on Pharmaceuticals and EDCs



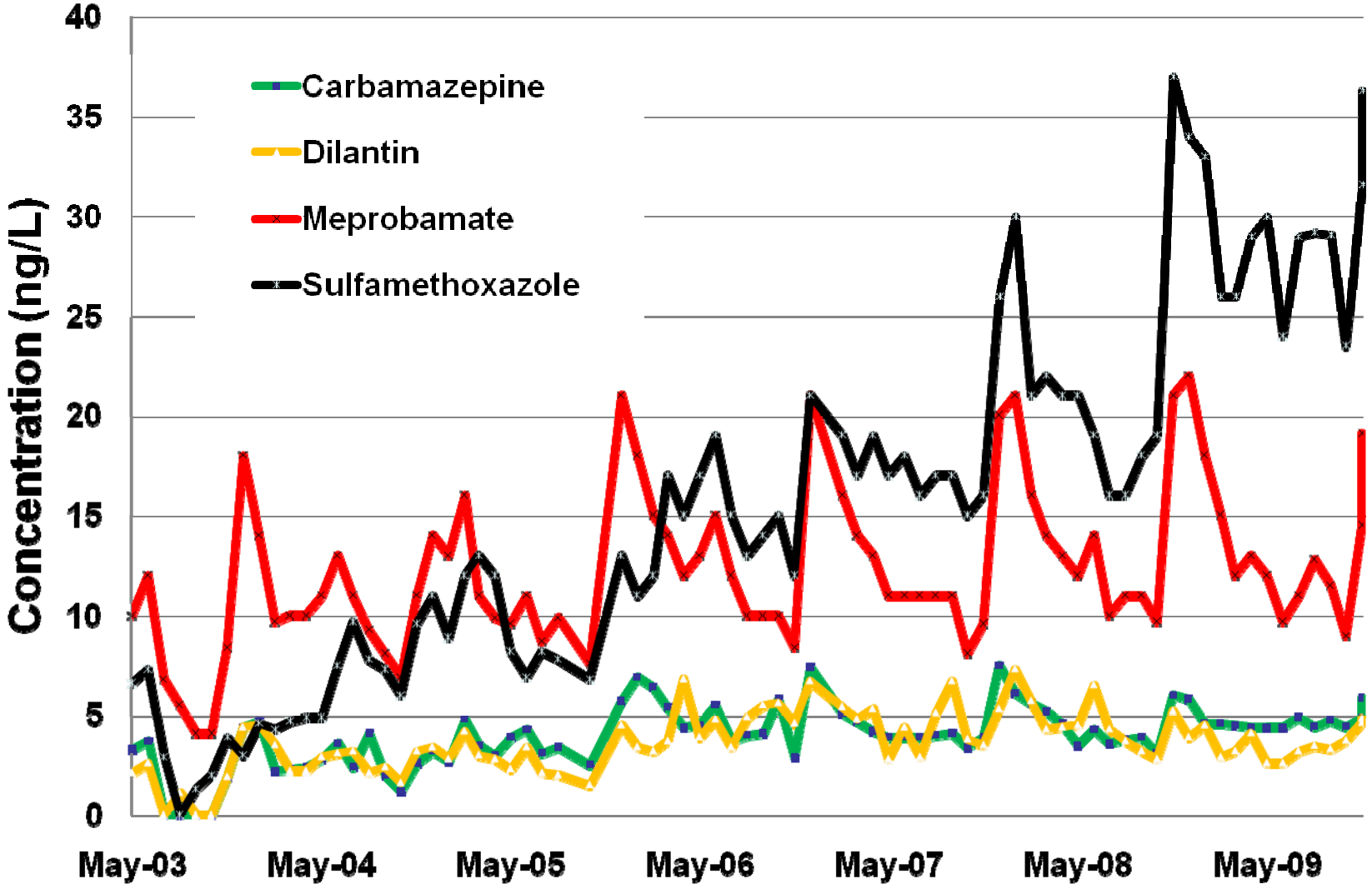
Endocrine disruptors and pharmaceuticals: implications for water sustainability

Shane A. Snyder and Mark J. Benotti

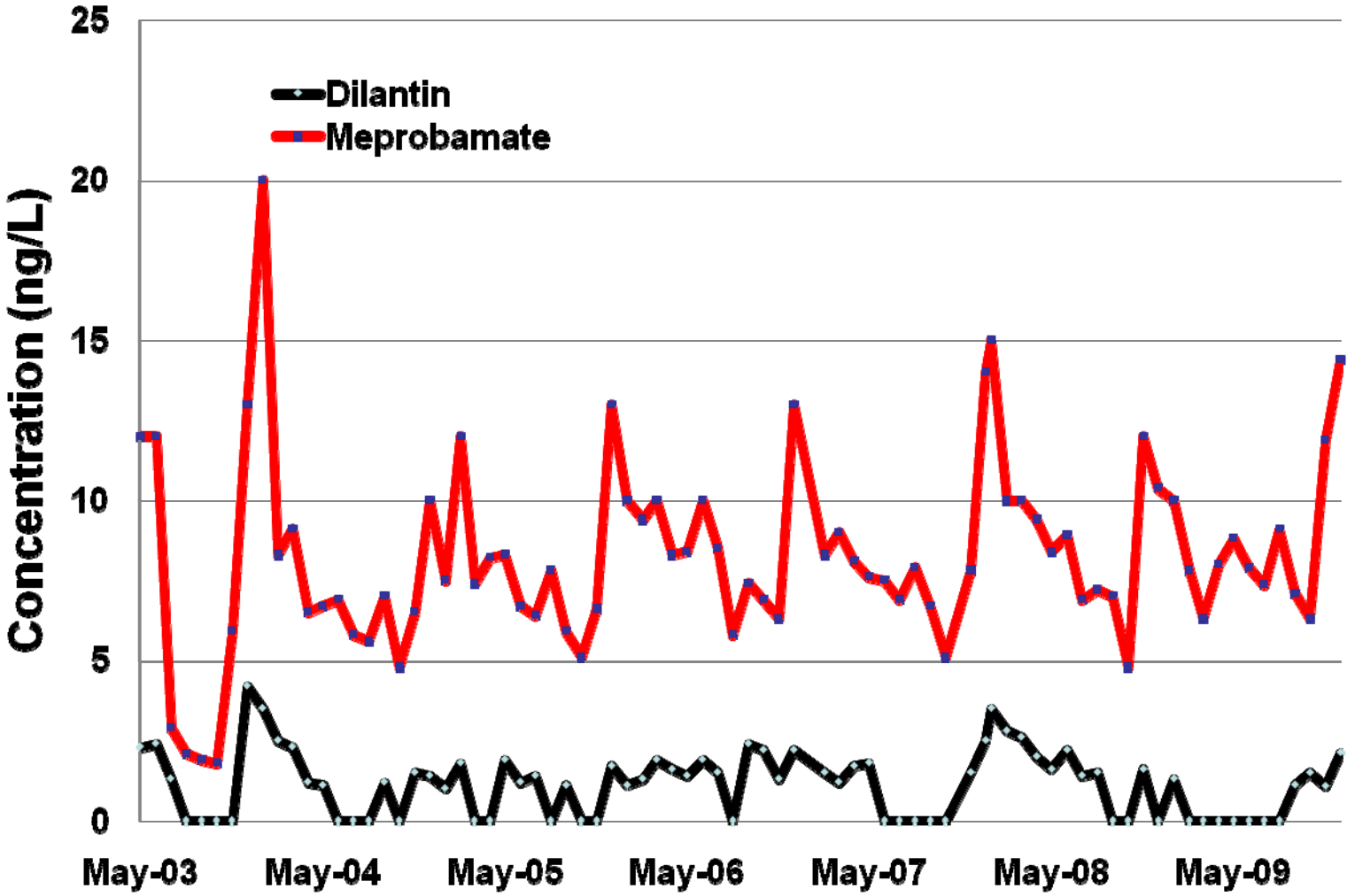
Las Vegas Wash monitoring – 5 years



Lake Mead monitoring – 6+ years



Finished drinking water monitoring – 6+ years



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California Urban Water Agencies

Tailored Collaboration

Toxicological Relevance of EDCs and Pharmaceuticals in Drinking Water

Subject Area:
Environmental Leadership

Toxicological Relevance of EDCs and Pharmaceuticals in Drinking Water

Prepared by:
Shane A. Snyder and **Rebecca A. Trenholm**
Southern Nevada Water Authority
Applied Research and Development Center, Henderson, NV 89015

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Intertox, Inc., Seattle, WA 98121

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Tailored Collaboration partners:
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Environ. Sci. Technol. **2009**, *43*, 597–603

Pharmaceuticals and Endocrine Disrupting Compounds in U.S. Drinking Water

MARK J. BENOTTI,
REBECCA A. TRENHOLM,
BRETT J. VANDERFORD,
JANIE C. HOLADY,
BENJAMIN D. STANFORD, AND
SHANE A. SNYDER*

Applied Research and Development Center, Southern Nevada Water Authority, P.O. Box 99954, Las Vegas, Nevada 89193-9954

some researchers have postulated that the long-term risk to humans from any single pharmaceutical at sub-μg/L levels is negligible (*8*), it is not clear what toxicological implications chronic exposure to suites of trace contaminants may pose (*9, 10*). The degree to which this issue has drawn interest across disciplines is illustrated by the voices of concern stemming from medical professionals, environmental scientists, drinking water municipalities, government agencies, and the general media (*9, 11*−*13*). However, if risk assessors and epidemiologists are to link any potential health outcomes with pharmaceutical and EDC exposure, a better understanding of their occurrence in drinking water is critical.

There is relatively sparse information regarding pharmaceutical and EDC occurrence in drinking water. Researchers in Germany measured ng/L concentrations of clofibric acid in Berlin tap water (*14*), a case which remains

Environ. Sci. Technol. **2010**, *44*, 5619–5626

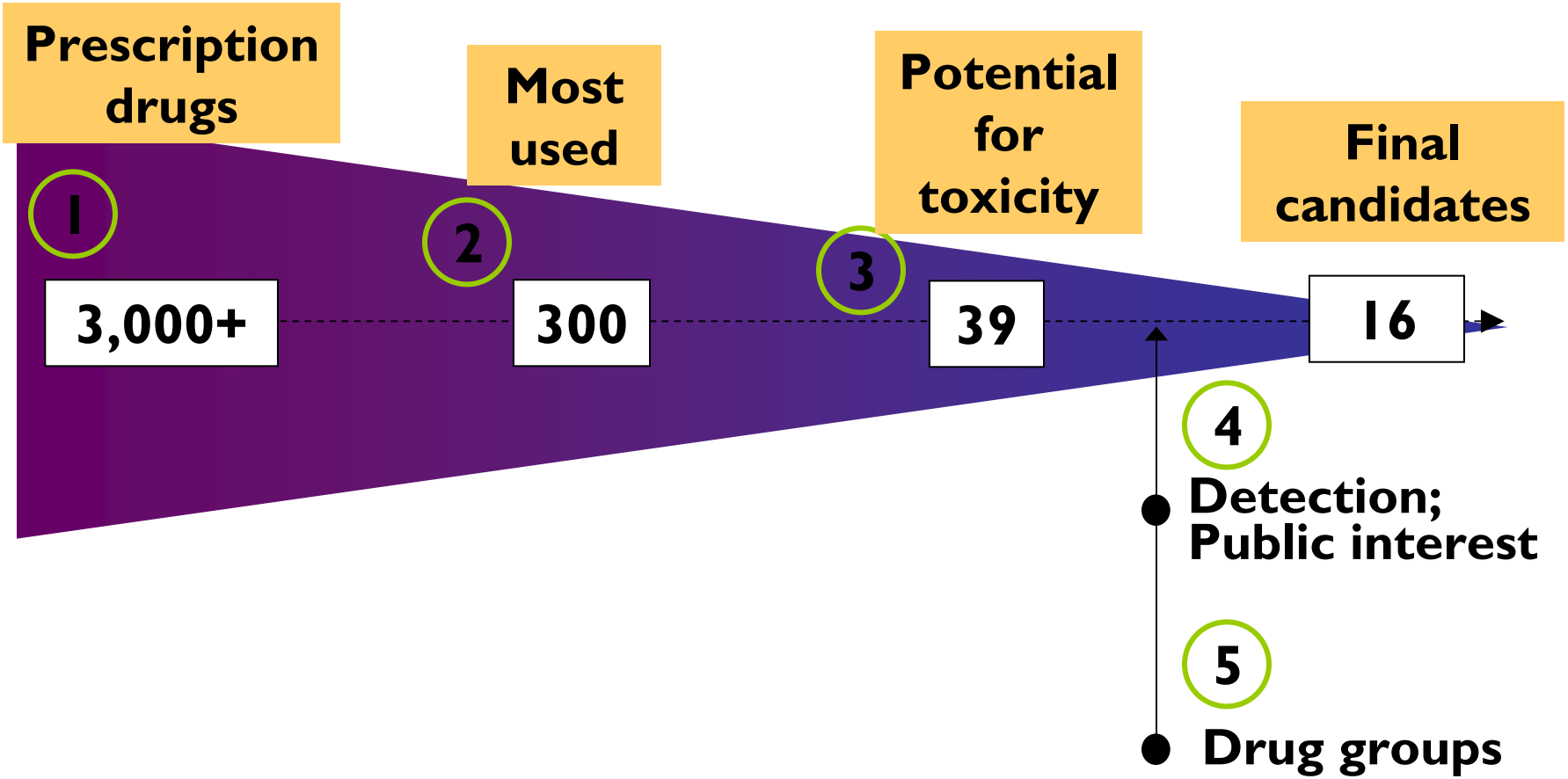
Toxicological Relevance of Pharmaceuticals in Drinking Water

GRETCHEN M. BRUCE,*,†
RICHARD C. PLEUS,† AND
SHANE A. SNYDER‡

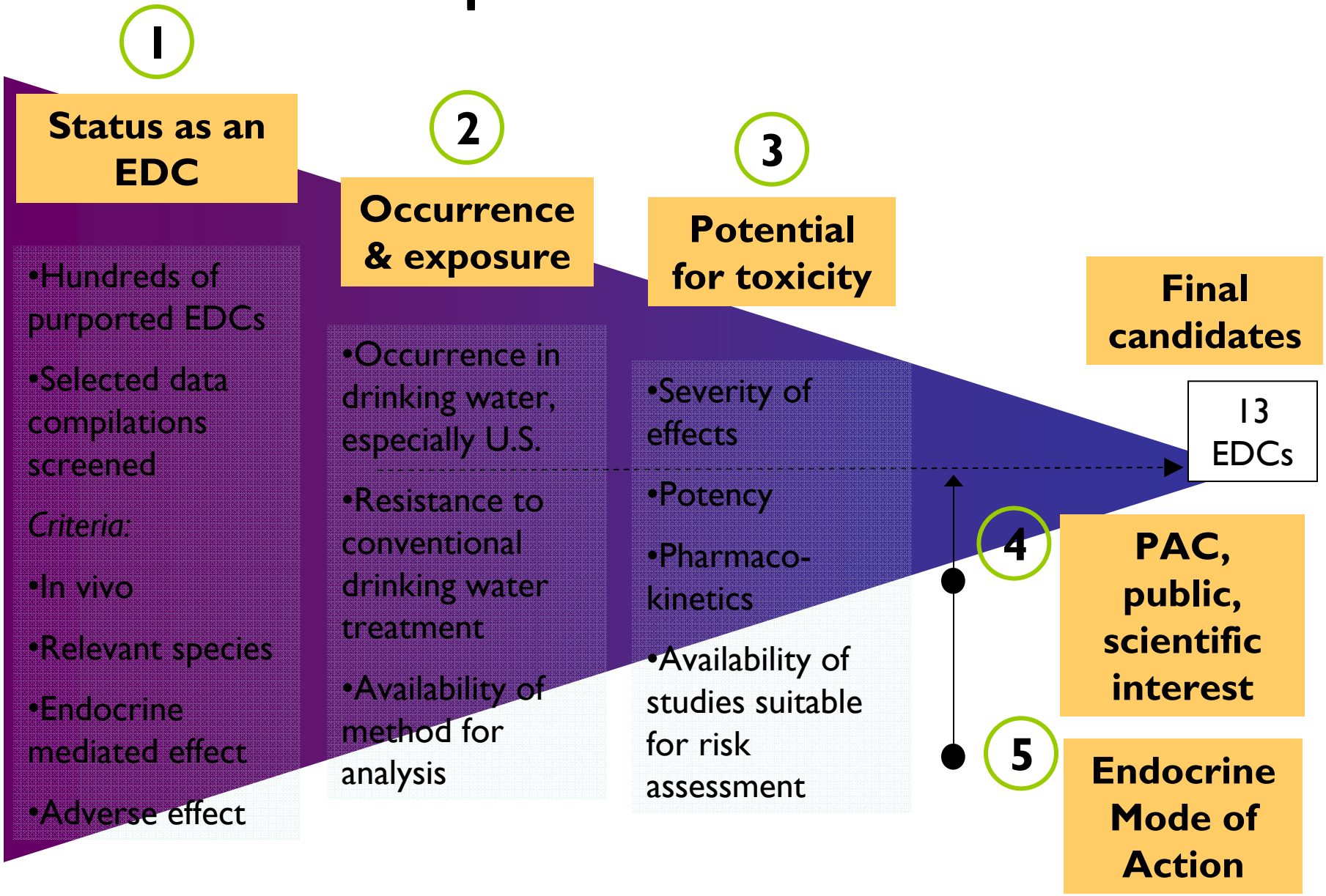
Intertox, Inc., 600 Stewart Street, Suite 1101, Seattle, Washington 98101, and Southern Nevada Water Authority, Applied R&D Center, 1001 S. Valley View Boulevard, Las Vegas, Nevada 89153

mode of action in mind..., they can also have numerous effects on nontarget, or as yet unknown, receptors and possibly cause side effects in the target organism" (*1*). Although no regulatory limits have been established for pharmaceuticals in drinking water, agencies are beginning to recommend monitoring (*4, 5*). The California Department of Health Services specified in its Draft Groundwater Recharge Reuse Regulations that PPCPs, endocrine disrupting compounds (EDCs), hormones, and other indicator compounds should be monitored in recycled water used to recharge groundwater basins designated as domestic water supplies (*4*). In its third Contaminant Candidate List (CCL3), the U.S. EPA has listed

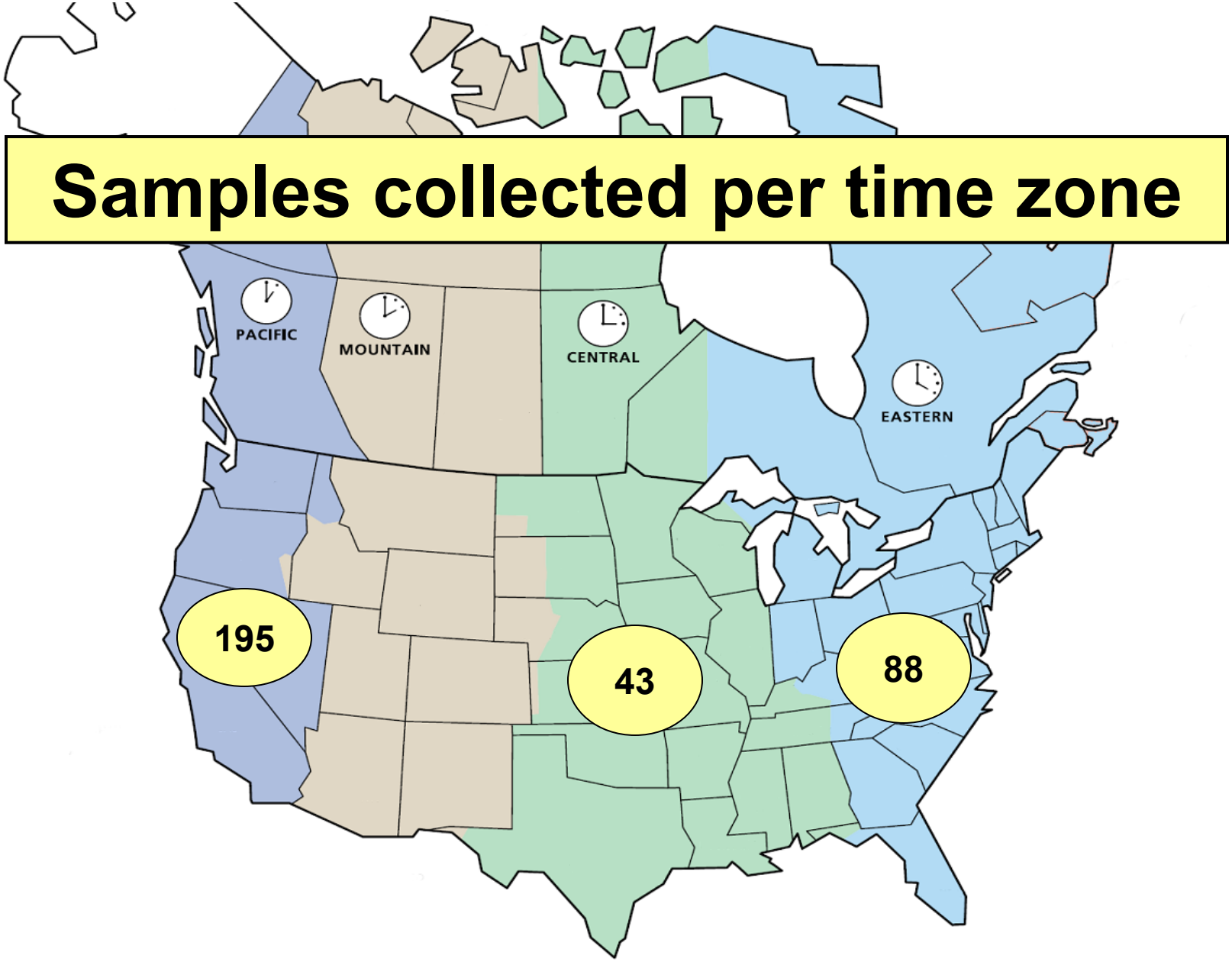
Pharmaceuticals



Suspected EDCs



Samples collected per time zone



17 Participating Utilities

Target Compounds

Pharmaceuticals (20)

- **Atenolol**
- **Atorvastatin**
- ***o-Hydroxy atorvastatin***
- ***p-Hydroxy atorvastatin***
- **Carbamazepine**
- **Diazepam**
- **Diclofenac**
- **Dilantin**
- **Enalapril**
- **Fluoxetine**
- ***Norfluoxetine***
- **Gemfibrozil**
- **Meprobamate**
- **Naproxen**
- **Risperidone**
- **Simvastatin**
- ***Simvastatin hydroxy acid***
- **Sulfamethoxazole**
- **Triclosan**
- **Trimethoprim**

Potential EDCs (26)

- **Atrazine**
- **Benzophenone**
- **BHA**
- **BHT**
- **α-BHC**
- **β-BHC**
- **γ-BHC**
- **δ-BHC**
- **Bisphenol A**
- **Butylbenzyl phthalate**
- **DEET**
- **Diazinon**
- **Dioctyl phthalate**
- **Galaxolide**
- **Linuron**
- **Methoxychlor**
- **Metolachlor**
- **Musk ketone**
- **Nonylphenol**
- **Octachlorostyrene**
- **Octylphenol**
- **TCEP**
- **TCPP**
- **Tonalide**
- **Traseolide**
- **Vinclozolin**

Steroid Hormones (5)

- **Estradiol**
- **Estrone**
- **Ethinylestradiol**
- **Progesterone**
- **Testosterone**

Phytoestrogens (11)

- **Apigenin**
- **Biochanin A**
- **Chrysin**
- **Coumestrol**
- **Daidzein**
- **Equol**
- **Formononetin**
- **Genistein**
- **Glycitein**
- **Matairesinol**
- **Naringenin**

Detected in Raw Water* (24/62)

Pharmaceuticals

Atenolol
Atorvastatin
o-Hydroxy atorvastatin
p-Hydroxy atorvastatin
Carbamazepine
Diazepam
Diclofenac
Dilantin
Enalapril
Fluoxetine
Norfluoxetine
Gemfibrozil
Meprobamate
Naproxen
Risperidone
Simvastatin
Simvastatin hydroxy acid
Sulfamethoxazole
Triclosan
Trimethoprim

Potential EDCs

Atrazine
Benzophenone
BHA
BHT
α-BHC
β-BHC
γ-BHC
δ-BHC
Bisphenol A
Butylbenzyl phthalate
DEET
Diazinon
Dioctyl phthalate
Galaxolide
Linuron
Methoxychlor
Metolachlor
Musk ketone
Nonylphenol
Octachlorostyrene
Octylphenol
TCEP
TCPP
Tonalide
Traseolide
Vinclozolin

Steroid Hormones

Estradiol
Estrone
Ethinylestradiol
Progesterone
Testosterone

Phytoestrogens

Apigenin
Biochanin A
Chrysin
Coumestrol
Daidzein
Equol
Formononetin
Genistein
Glycitein
Matairesinol
Naringenin

*** In at least 20% of samples**

Detected in Drinking Water* (11/62)

Pharmaceuticals	Potential EDCs	Steroid Hormones	Phytoestrogens
Atenolol	**Atrazine**	Estradiol	Apigenin
Atorvastatin	Benzophenone	Estrone	Biochanin A
o-Hydroxy atorvastatin	BHA	Ethinylestradiol	Chrysin
p-Hydroxy atorvastatin	BHT	Progesterone	Coumestrol
Carbamazepine	α-BHC	Testosterone	Daidzein
Diazepam	β-BHC		Equol
Diclofenac	γ-BHC		Formononetin
Dilantin	δ-BHC		Genistein
Enalapril	Bisphenol A		Glycitein
Fluoxetine	Butylbenzyl phthalate		Matairesinol
Norfluoxetine	**DEET**		Naringenin
Gemfibrozil	Diazinon		
Meprobamate	Dioctyl phthalate		
Naproxen	Galaxolide		
Risperidone	Linuron		
Simvastatin	Methoxychlor		
Simvastatin hydroxy acid	**Metolachlor**		
Sulfamethoxazole	Musk ketone		
Triclosan	Nonylphenol		
Trimethoprim	Octachlorostyrene		
	Octylphenol		
	TCEP		
	TCPP		
	Tonalide		
	Traseolide		
	Vinclozolin		

*** In at least 20% of samples**

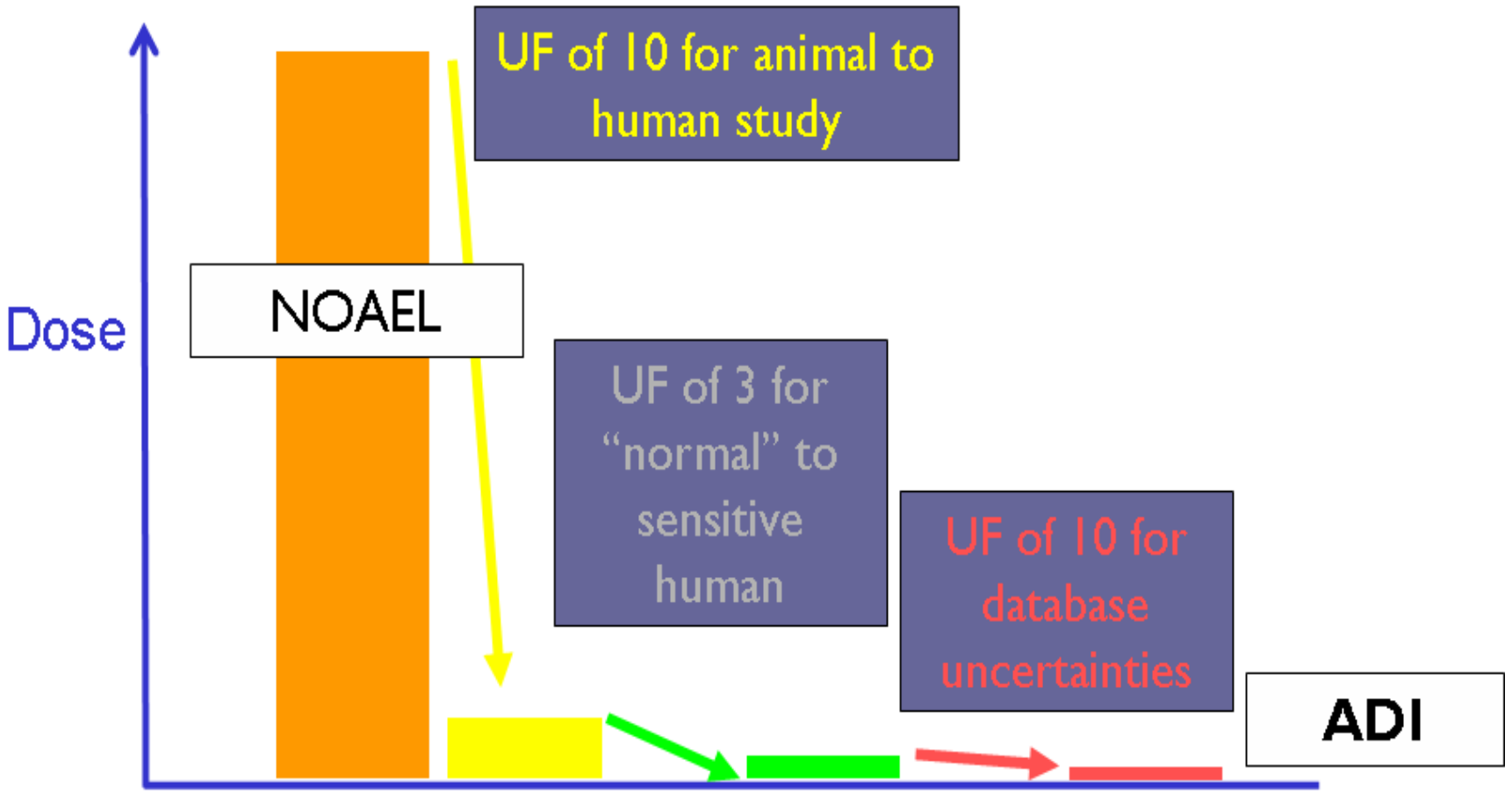
US Drinking Water

Finished Water for 18 Drinking Water Treatment Facilities			
Compound	Max (ng/L)	Median (ng/L)	Frequency (%)
Atrazine	870	49	83
Meprobamate	42	5.7	78
Dilantin	19	6.2	56
Atenolol	18	1.2	44
Carbamazepine	18	6.0	44
Gemfibrozil	2.1	0.48	39
TCEP	470	120	39
DEET	93	63	33
Metolachlor	27	16	33
TCPP (Fyrol PCF)	510	210	28
Sulfamethoxazole	3.0	0.39	22

Detected in systems with chloramination or UV

DWEL ≈ MCLG

Drinking Water Equivalent Level (DWEL) = $\frac{\text{ADI} * 70\ \text{kg}}{2\ \text{L}}$



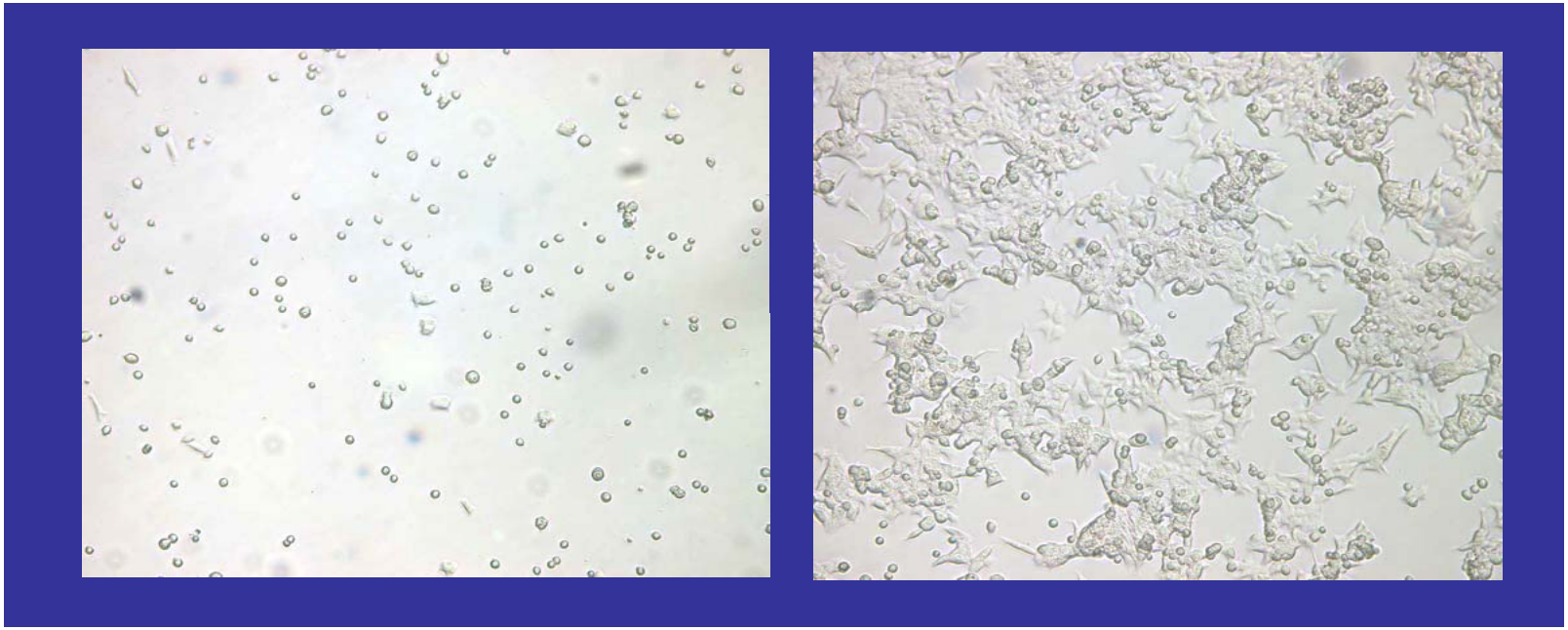
Pharmaceutical Evaluation

Drug	Class	ADI-DWEL (µg/L)	Max. conc. (µg/L)	Sites with Detection (n=18)	Liters per Day to Exceed DWEL
Risperidone	Antipsychotic	0.49	0.0029	1	340
Phenytoin	Anticonvulsant	6.8	0.019	10	700
Carbamazepine	Anticonvulsant	12	0.018	8	1,300
Atenolol	Beta-blocker	70	0.018	8	7,800
Meprobamate	Antianxiety agent	260	0.042	14	13,000
Gemfibrozil	Antilipidemic	45	0.0021	7	43,000
Fluoxetine	SSRI antidepressant	34	0.00082	2	82,000
Norfluoxetine	Metabolite	34	0.00077	1	88,000
Diazepam	Benzodiazepine tranquilizer	35	0.00033	1	210,000
Sulfamethoxazole	Anti-infective	18,000	0.003	4	12,000,000

Bruce, Pleus, & Snyder, 2010 Environ. Sci. Technol. 44:5619-5626

E-screen Assay

- MCF-7 breast cancer cell line proliferates in response to estrogenic compounds
- Developed by oncologists Ana Soto & Carlos Sonnenschein at Tufts University



EEq Comparison ("Worst" WWTP)

Mug of Beer
(6 ng/L, 500 mL)

1.4 L Wastewater
(4.6 ng/L)

EEq Comparison ("Worst" WWTP)

≈

1 cup coffee
(17 ng/L, 240 mL)

890 mL Secondary Wastewater
(4.6 ng/L)

EEq Comparison
"Worst" WWTP

≈

Teaspoon of Soy Sauce
(300 ng/L, 15 mL)

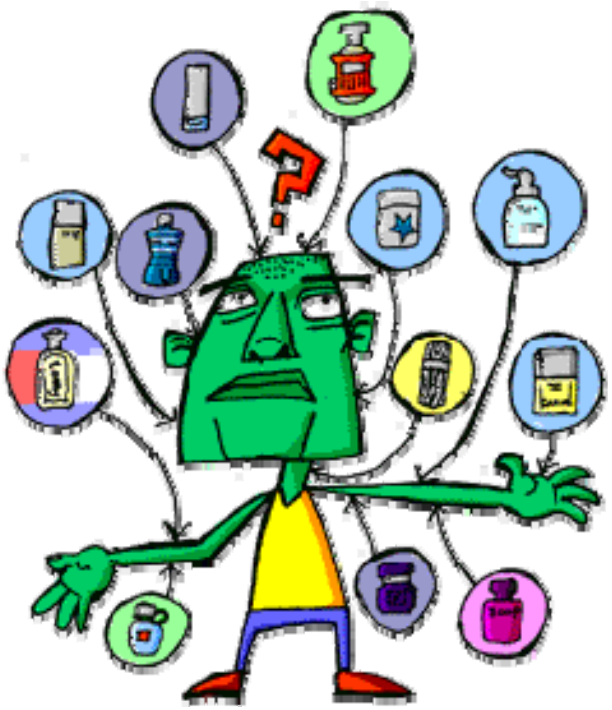
1 Liter Secondary Wastewater
(4.6 ng/L)

Three Key Points

I. Trace contaminants are ubiquitous in water

II. Ecological impacts demonstrated, human unlikely

III. Public perception and trust are critical for water reuse



US Regulatory History

- 1962: 28 discrete "chemical" contaminants regulated

5.21 The following chemical substances should not be present in a water supply in excess of the listed concentrations where, in the judgment of the Reporting Agency and the Certifying Authority, other more suitable supplies are or can be made available.

Substance	*Concentration in mg/l*
Alkyl Benzene Sulfonate (ABS)	0.5
Arsenic (As)	0.01
Chloride (Cl)	250.
Copper (Cu)	1.
Carbon Chloroform Extract (CCE)	0.2
Cyanide (CN)	0.01
Fluoride (F)	(See 5.23)
Iron (Fe)	0.3
Manganese (Mn)	0.05
Nitrate [1] (NO_3)	45.
Phenols	0.001
Sulfate (SO_4)	250.
Total Dissolved Solids	500.
Zinc (Zn)	5.

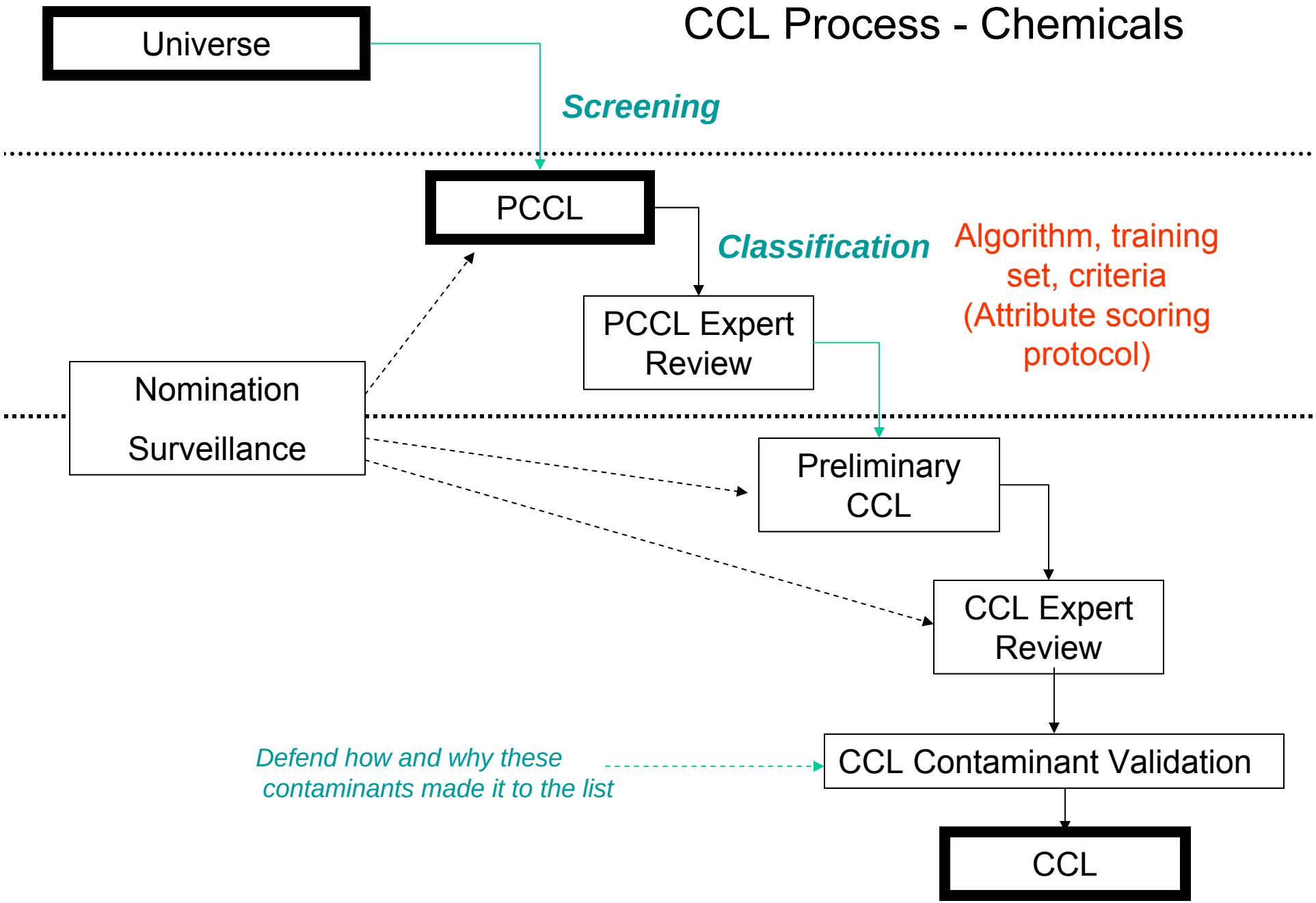
US Regulatory History

- 1962: 28 discrete "chemical" contaminants regulated

Concentrations of anionic surfactants found in drinking waters have ranged from 0 to 2.6 mg/1 in well water supplies and from 0 to 5 mg/1 in river water supplies. In one instance, a municipal water supply contained 5 mg/1 when a period of drought necessitated use of an impounded, highly purified sewage treatment plant effluent as a raw water supply (4).

than from ABS. The concentration of ABS in municipal sewage is of the order of 10 mg/1. Thus waters containing ABS are likely to be at least 10 percent of sewage origin for each mg ABS/1 present.

It is recommended that alkyl benzene sulfonate (ABS) in drinking water be limited to 0.5 mg/1, inasmuch as higher concentrations may cause the water to exhibit undesirable taste and foaming. Concentrations of ABS above 0.5 mg/1 are also indicative of questionably undesirable levels of other sewage pollution.


CCL Process - Chemicals
Universe
Screening
PCCL
Classification
Algorithm, training set, criteria (Attribute scoring protocol)
PCCL Expert Review
Nomination
Surveillance
Preliminary CCL
CCL Expert Review
Defend how and why these contaminants made it to the list
CCL Contaminant Validation
CCL

CCL3 – Key Highlights

- Draft CCL3 – essentially no pharmaceuticals or steroids
  - Did include PFOA and PFOS
  - Did include nitroglycerine (but not for pharmaceutical reasons)
- Final CCL3 – addition of 9 estrogens, 1 progestin, & 1 antibiotic
  - Estrogens (17a-estradiol, 17b-estradiol, equilenin, equilin, estriol, estrone, ethynylestradiol, estriol, estrone, mestranol)
  - Progestin (norethindrone)
  - Antibiotic (erthythromycin)
- Steroid hormones on CCL3 largely due to:
  - Kolpin 2002 (USGS) – hormones at hundreds of ng/L
  - California E2 Cancer Risk – DWEL = 0.9 ng/L

Contaminant:	Estradiol (17-beta estradiol)

Attribute Scores			
Potency	**Severity**	**Prevalence**	**Magnitude**
8	**8**	**10**	**5**

3-model Categorical Prediction
L
HRL Ratio(s)
NC HRL/Kolpin MAX: 1.75 **CAR HRL/Kolpin MAX: 0.0045**

Health Reference Level (HRL)[2] cancer	0.0009 ug/L

Water Data	% Detects	Maximum value of Detects	Median value of Detects	90% of Detects	Units for Mag data
Snyder, et al., 2007 FINISHED	0.0	Not detected	Not detected	Not detected	ug/L
Snyder, et al., 2007 RAW		0.0064			ug/L
Kolpin, et al., 2002	**10.6**	**0.2**	**0.16**		**ug/L**

Summary of Evaluations Performed by the Joint FAO/WHO Expert Committee on Food Additives (JECFA 1956-2004) (First through sixty-third meetings)

Summary of Evaluations Performed by the Joint FAO/WHO Expert Committee on Food Additives

ESTRADIOL-17BETA	
Chemical names:	ESTRA-1,3,5(10)-TRIENE-3,17beta-DIOL
Synonyms:	**ESTRADIOL**
Functional class:	VETERINARY DRUG (PRODUCTION AID)
Latest evaluation:	1999
ADI:	0-0.00005 mg/kg bw **= 50 ng/Kg = 3500 ng/70 Kg person**
Comments/MRLs:	MRLs: Muscle, liver, kidney and fat (cattle): NOT SPECIFIED
Report:	TRS 893-JECFA 52/57
Residues:	FNP 41/12-JECFA 52/37
Tox monograph:	FAS 43-JECFA 52/43
Previous status:	1987, TRS 763-JECFA 32/17, FNP 41-JECFA 32/7, NOT PREPARED. ADI UNNECESSARY. ACCEPTABLE RESIDUE LEVEL: UNNECESSARY; HORMONE PRODUCED ENDOGENOUSLY AT VARIABLE LEVELS IN HUMAN BEINGS. RESIDUES FROM USE IN ACCORDANCE WITH GOOD ANIMAL HUSBANDRY PRACTICE UNLIKELY TO POSE A HAZARD TO HUMAN HEALTH. AC. MRL 1981, TRS 669-JECFA 25/15. UNLIKELY TO BE ANY CAUSE OF CONCERN WHEN PROPERLY USED

BUT What about the MIXTURES?

WHO – Drinking Water Quality Guidelines

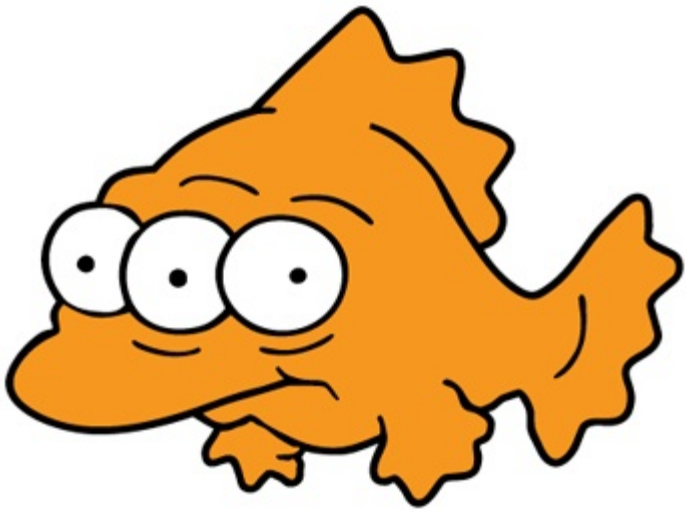
8.2.9 Mixtures

Chemical contaminants of drinking-water supplies are present with numerous other inorganic and/or organic constituents. The guideline values are calculated separately for individual substances, without specific consideration of the potential for interaction of each substance with other compounds present. The large margin of uncertainty incorporated in the majority of the guideline values is considered to be sufficient to account for potential interactions. In addition, the majority of contaminants will not be continuously present at concentrations at or near their guideline value.

washingtonpost.com

Male Bass Across Region Found to Be Bearing Eggs

Pollution Concerns Arise In Drinking-Water Source



By David A. Fahrenthold
Washington Post Staff Writer
Wednesday, September 6, 2006; A01

Abnormally developed fish, possessing both male and female characteristics, have been discovered in the Potomac River in the District and in tributaries across

Sewage Altering Fish, Study Reports

Male bottom-dwellers with female sex characteristics are found near outfall pipes in waters off Los Angeles and Orange counties.

By Marla Cone
Times Staff Writer

Los Angeles Times

November 14, 2005

Male fish with female characteristics have been discovered in ocean waters off Los Angeles and Orange counties, raising concerns that treated sewage released offshore contains hormone-disrupting compounds that are deforming the sex organs of marine life.

PNAS | May 22, 2007 | vol. 104 | no. 21 | 8897–8901

Collapse of a fish population after exposure to a synthetic estrogen

Karen A. Kidd*†, Paul J. Blanchfield*, Kenneth H. Mills*, Vince P. Palace*, Robert E. Evans*, James M. Lazorchak‡, and Robert W. Flick‡

- Dosed entire lake with ≈6 ng/L of ethynylestradiol (EE2)
  - Compared to two reference Lakes (pristine)
  - Seven years of monitoring, three years of dosing EE2
- Fathead minnow population dwindled to near extinction
  - Male fish had VTG levels 1000x higher than controls
  - Histological impacts, including intersex, observed
  - Reproductive failure persisted 2-year after exposure ceased
- *Only* study showing pop. impact of a pharm. in water

Chronic Toxicity of Zinc to the Fathead Minnow, Pimephales promelas Rafinesque

William A. Brungs

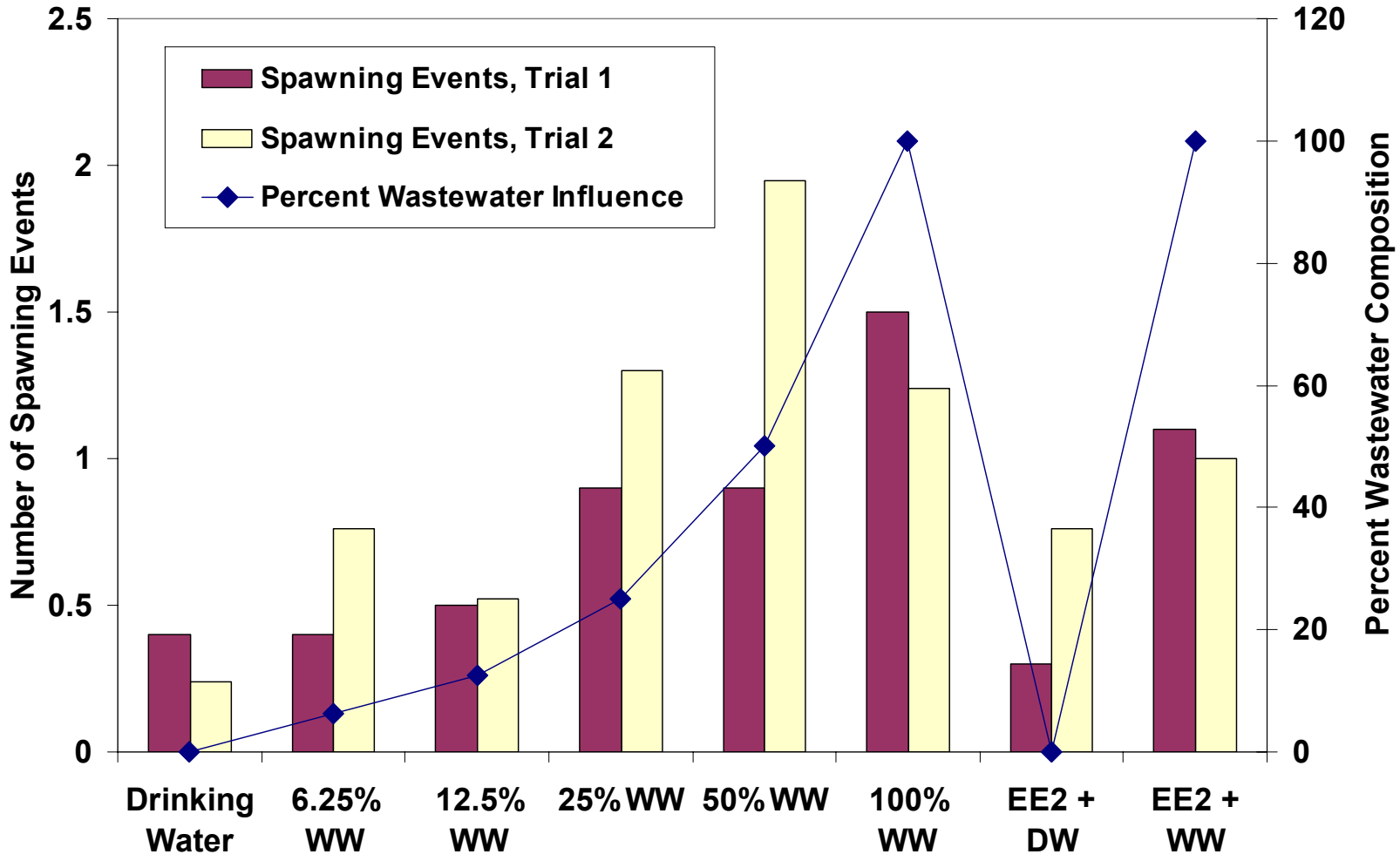
National Water Quality Laboratory, Newtown Fish Toxicology Laboratory, Federal Water Pollution Control Administration, U. S. Department of the Interior, Cincinnati, Ohio 45244

1969, *Transactions of the American Fisheries Society*;

Zn 50% Spawning Reduction = 88 µg/L

Drinking Water Zn > 150 µg/L

Wastewater Zn < 50 µg/L



Three Key Points

- *All water has been, or will be, reused*
  - Global sustainability depends on recycling water
  - Analytical instruments can detect nearly any substance
- *Pharmaceuticals can be measured ubiquitously*
  - But, analytical methods are not yet standardized
  - Lists if pharmaceuticals are largely arbitrary
- *Public perception and trust are critical*
  - Human and fish exposure is dramatically different
  - Help fish through reuse of surface discharge for potable reuse
  - We have challenges, but should focus on those that matter
  - Regulations MAY help with public perception, but move slowly

The Path Forward

Increased reuse of water

-Especially in coastal cities

-More efficient technologies

-Direct reuse

- -Not just in African anymore
  - -Cloudcroft, NM
  - -Amarillo, TX
  - -Your town?
- -What does the environmental buffer contribute to safety?

-Right quality of water for use

- -Toilet flushing vs. drinking
- -Lawn irrigation vs. bathing

Life Cycle of Water

Water Scarcity:

Global Implications for Industrial and Domestic

Water Reuse

January 13-14, 2011

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