# Constituents of Emerging Concern: State of Regulatory Developments and Science

2015 Idaho Water Reuse Conference,
Boise, ID, May 26-27

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Engineers...Working Wonders With Water®

# Agenda

- Terminology
- Sources of CEC
- Public Communication Strategies
- Regulatory Developments
- State of the Science
  - Treatment Effectiveness (conventional, advanced)
  - Biosolids Land Application
  - Agricultural Reuse
  - CEC Management in Watersheds

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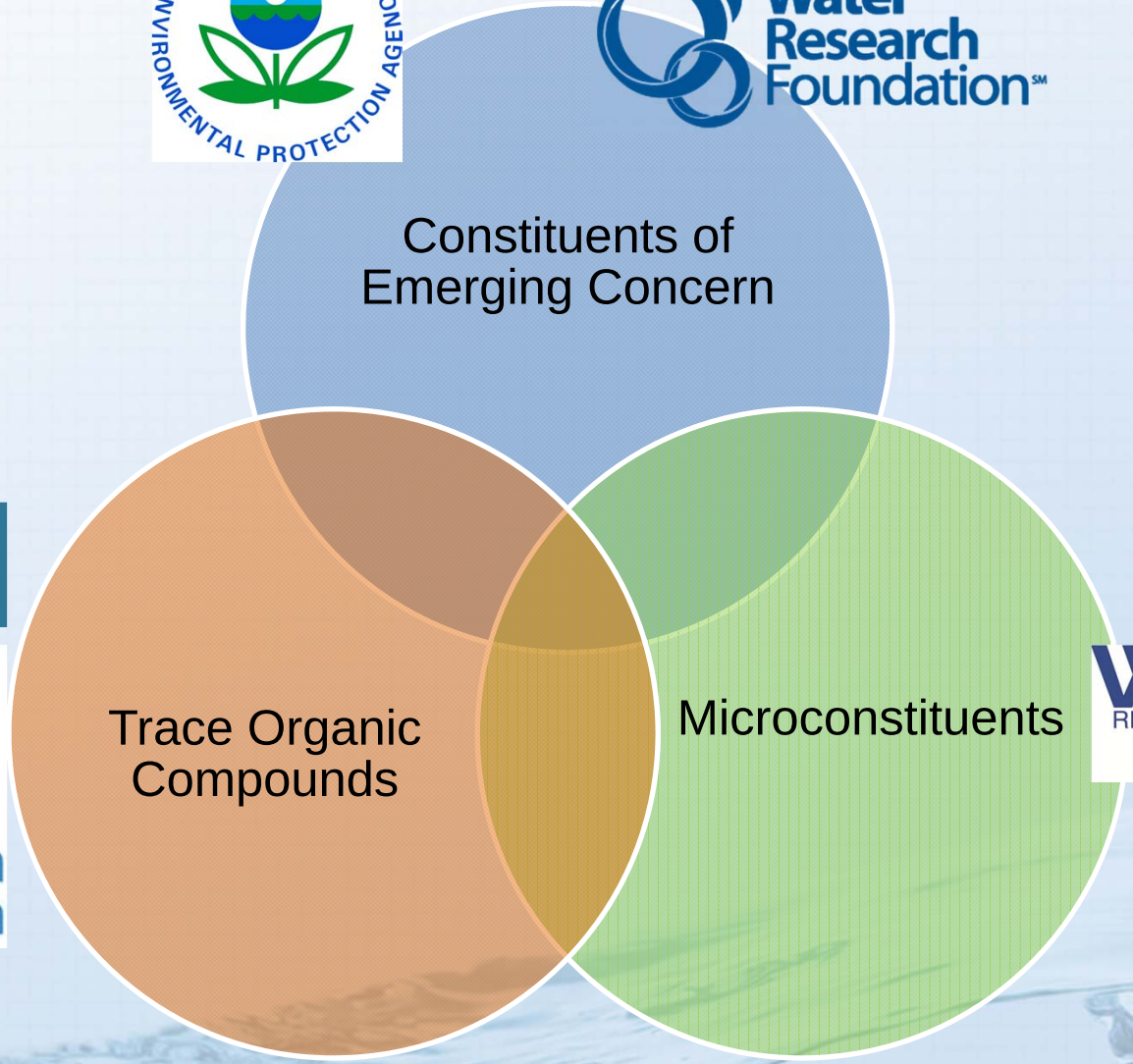
# CEC Terminology can be Confusing

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***http://www.cas.org/***

## Pharmaceuticals

| | |
|---|---|
| Sulfamethoxazole | Antibiotic |
| Fluoxetine | Antidepressant |

## Disinfection By-Products

NDMA

## Pesticides

Atrazine

## Algae Toxins

## Nanoparticle

Silvers

## Food Additives

| | |
|---|---|
| Caffeine | Stimulant |
| Sucralose | Artificial Sweetener |

## Personal Care Products

| | |
|---|---|
| Benzophenone | UV-Blocker |
| DEET | Insect Repellent |
| Triclocarban | Anti-Bacterial / Antifungal |
| Triclosan | Anti-Bacterial / Antifungal |

## Industrial Chemicals

| | |
|---|---|
| Bisphenol A | Plasticizer |
| TCPP | Flame Retardant |
| TCEP | Flame Retardant |

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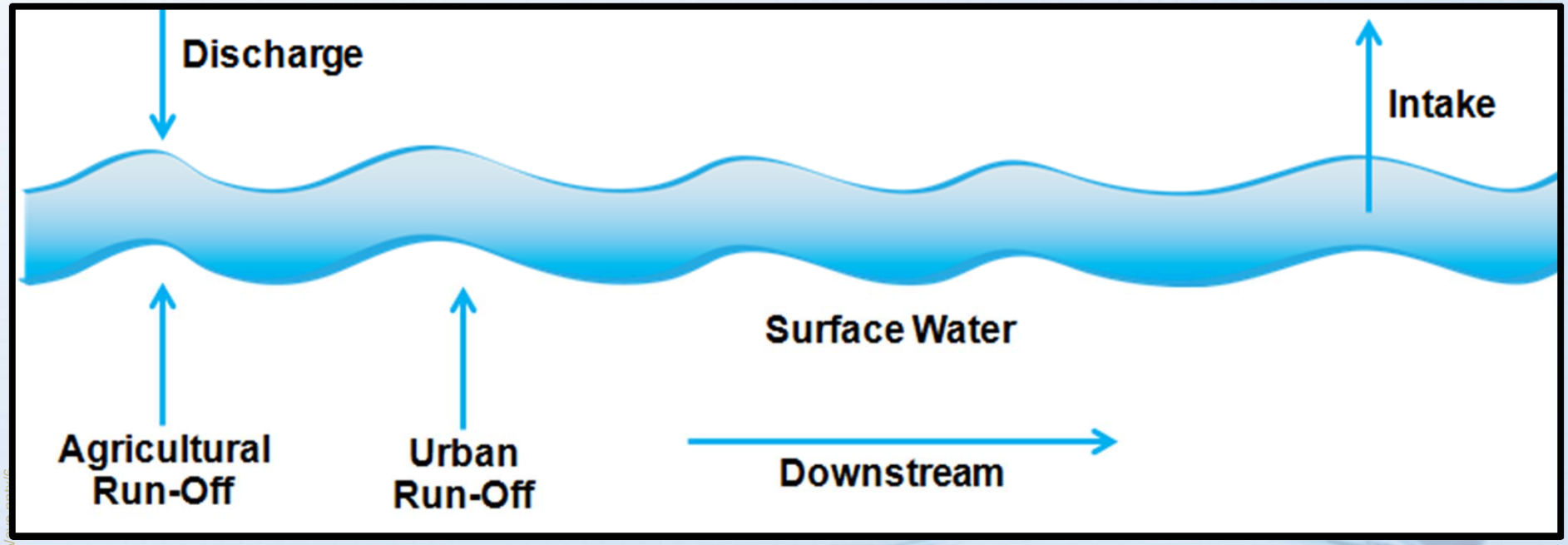
# Many CECs Originate from Products We Consume on a Daily Basis

# CECs Enter the Environment from Point and Non-Point Sources

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# Human and Eco Health Impacts Vary

# Amount of Water to Meet Acceptable Daily Intake (for Humans) - Pharmaceuticals

| | ADI-DWEL | Maximum Water Conc. Finished | Amount of water to meet ADI | | |
|---|---|---|---|---|---|
| | µg/L | µg/L | 8 oz Glasses/d | Gallons/d | 55-Gallon drums/d |
| Atenolol | 70 | 0.026 | 22,800 | 1,400 | 25 |
| Carbamazepine | 12 | 0.018 | 5,500 | 340 | 6.2 |
| Diazepam | 35 | 0.00033 | 890,000 | 55,000 | 1,000 |
| Fluoxetine | 35 | 0.00082 | 360,000 | 22,000 | 400 |
| Gemfibrozil | 45 | 0.0021 | 180,000 | 11,000 | 200 |
| Meprobamate | 260 | 0.043 | 51,000 | 3,200 | 58 |
| Phenytoin | 6.8 | 0.032 | 1,800 | 110 | 2.0 |
| Risperidone | 0.49 | 0.00034 | 12,000 | 770 | 14 |
| Sulfamethoxazole | 18,000 | 0.0030 | 51,000,000 | 3,200,000 | 58,000 |
| Triclosan | 2,600 | 0.0012 | 19,000,000 | 1,200,000 | 22,000 |

Credit: Shane Snyder, University of Arizona

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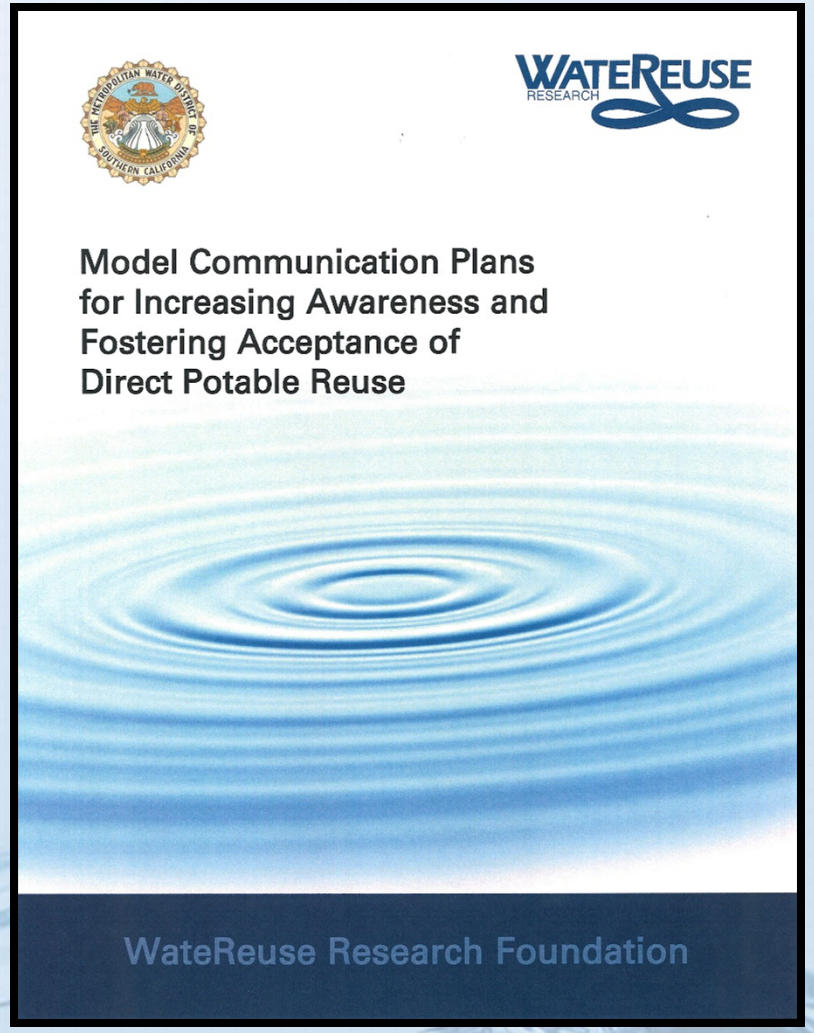
...AND A GLASS OF ICE WATER
YOU NEED A PRESCRIPTION FOR THAT
DRUGS IN TAP WATER

# Strategies for Communicating CEC and Water Reuse Issues with the Public

- Numerous WERF/WRRF/WRF studies to develop tools
- Key findings:
  - Start early with communication plan
  - Transparency builds trust
  - Consistent terminology clarifies confusion
  - Talk about de-facto reuse
  - Redundant treatment builds confidence
  - Site successful projects



# Main US Regulations

| | Eco Health | Human Health |
|---|---|---|
| | Clean Water Act | Safe Drinking Water Act |
| **Candidate Identification** | - | UCMR |
| | - | CCL |
| **Regulation** | Water quality standards | Drinking Water Standards |
| | NPDES Limits | |

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# UCMR3 – Monitoring List

| Assessment Monitoring (List 1 Contaminants) | | | |
|---|---|---|---|
| 1,4-dioxane | 1,2,3-trichloropropane | 1,3-butadiene | 1,1-dichloroethane |
| chloromethane (methyl chloride) | bromomethane (methyl bromide) | chlorodifluoromethane | bromochloromethane (Halon 1011) |
| Vanadium | Molybdenum | Strontium | Cobalt |
| Chromium-6 | Chromium-total | chlorate | Perfluorooctane sulfonic acid (PFOS) |
| perfluorooctanoic acid (PFOA) | perfluorononanoic acid (PFNA) | perfluorohexanesulfonic acid (PFHxS) | perfluoroheptanoic acid (PFHpA) |
| perfluorobutanesulfonic acid (PFBS) | | | |
| **Screening Survey (List 2 Contaminants)** | | | |
| estrone | 17β-estradiol | estriol | 17α-ethynylestradiol |
| equilin | testosterone | 4-androstene-3,17-dione | |
| **Pre-Screen Testing (List 3 Contaminants)** | | | |
| enteroviruses | noroviruses | | |

Synthetic Organic Compound (GC/MS) Volatile Organic Compounds (VOCs) (GC/MS) Metals (ICP/MS) Soluble chromate (ion) (IC/UV-VIS) Oxyhalide Anion (IC/Conductivity) Perfluorinated Chemicals (LC/MS/MS) Hormones (LC/MS/MS) Viruses (cell culture & qPCR)

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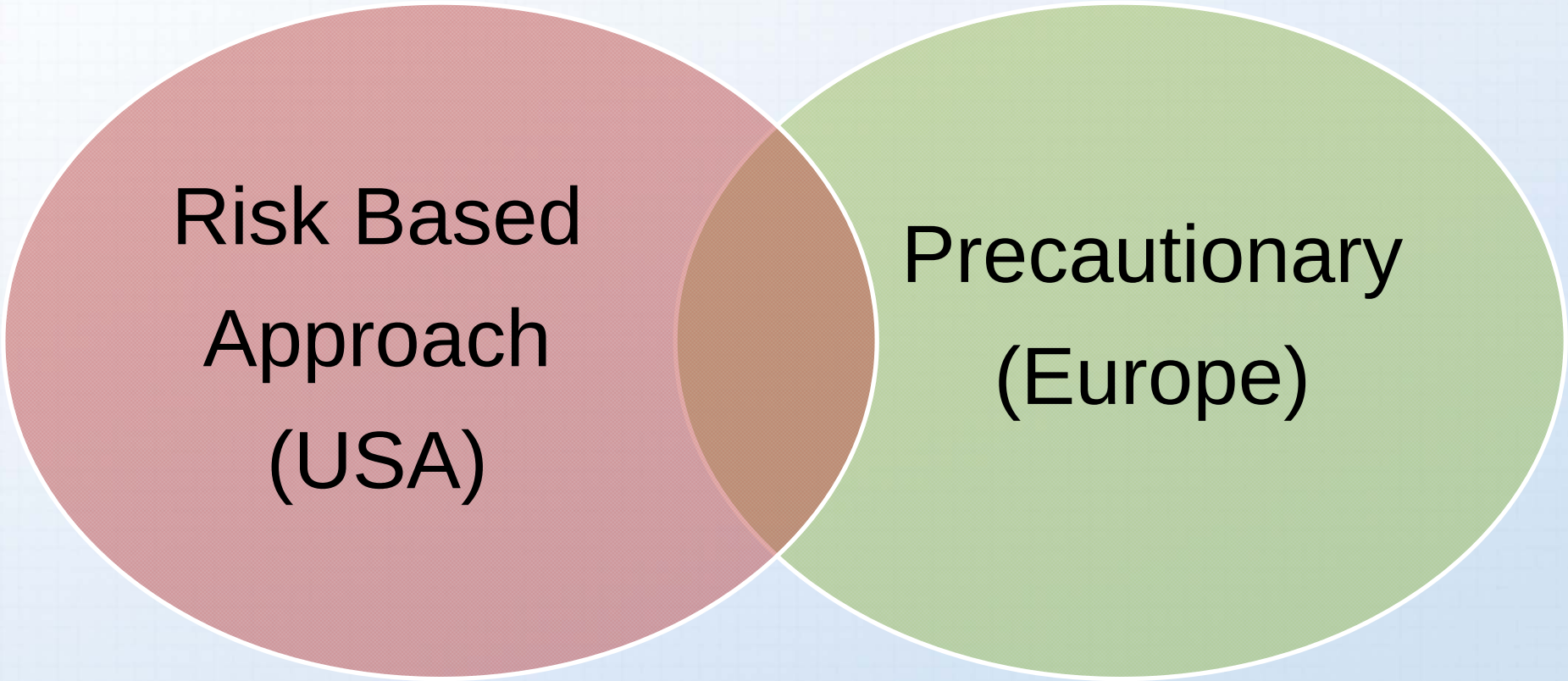
# 2015 Draft CCL4

| Compound Group | Example CCL4 Listing |
|---|---|
| Pesticides, Herbicides, Insecticides | Diuron |
| Hormones | 17-alpha estradiol |
| Pharmaceuticals / Anti-biotic | Erythromycin |
| Food Additive | Nonylphenol, PFOS, PFOA |
| Disinfection By-products | NDMA, other nitrosamines |

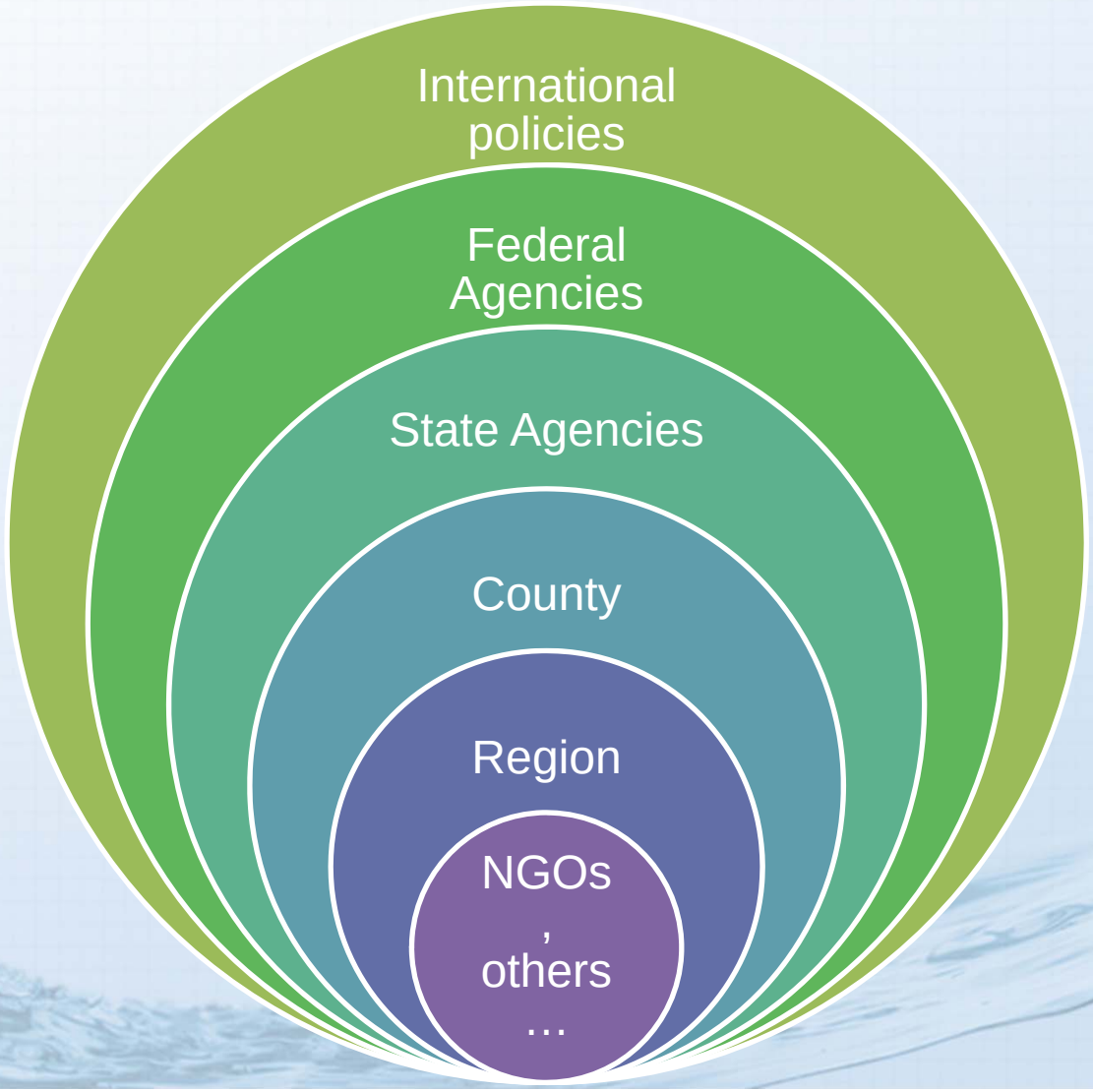
# CEC Management Varies Across the World




"Need to know the facts before taking action is justified."

"Take action as necessary to prevent potential risks, even if science is not yet fully understood."

# Who is Responsible for CECs Management in the USA?



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| Examples of State Programs for the Management of CECs | |
|---|---|
| **California** | • Draft regulations for the monitoring of CEC in groundwater recharge systems<br>• Science advisory panel to identify CECs monitoring list to assess CECs in the State's aquatic<br>• Regional and statewide discharge limits (e.g. NDMA, Perchlorate)<br>• California Safer Consumer Products Regulations (effective since 2013) |
| **Maine** | • 2007 Ban on flame retardants |
| **Maryland** | • Demonstrated endocrine effects on aquatic life in Chesapeake Bay and its tributaries<br>• Unsuccessful attempts to ban bisphenol-A and phthalates |
| **Massachusetts** | • Emerging Contaminant List and Screening<br>• 2004 Drinking water limit for perchlorate<br>• Measurements and safe handling of nanoparticles (Interagency Nanotechnology Committee) |
| **Oregon** | • Toxic Monitoring Program – State-wide environmental concentrations of toxics including CECs in water and biota<br>• Green Chemistry Innovation Initiative (Executive Order 5-12) |
| **Pennsylvania** | • Study on advanced oxidation for removal of hormones from drinking water |
| **Virginia** | • Extensive chemical and fish tissue testing program |
| **Washington** | • Puget Sound Partnership – Puget Sound Toxics Loading Study |

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  - Agricultural Reuse
  - CEC Management in Watersheds

# Ecological Health Impacts – How much Treatment is enough?

FEATURES

JANUARY 17, 2007

## A Fish Problem This Big

### Scientists, policymakers debate growing EDC pollution in Idaho waters

By Peter Wollheim

Whenever offered a glass of water, the great comedian W.C. Fields typically declined, on the grounds that fish have sex in it. But with the increasing spread of a class of chemicals called endocrine disruptor compounds (EDCs) in Idaho's watersheds, some experts wonder if local fish are at risk of losing their sexual and reproductive capacities.

click to enlarge

BEN WILSON

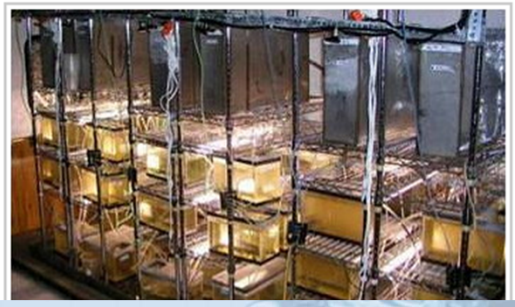
Despite scarce funding, the ramifications for human health still prompt research in this area.

The potential hazards of EDCs were first discovered in the 1990s among fish and amphibians that gather downstream from sewage treatment plants in Europe. These waters contain abnormally high concentrations of organic chemicals such as steroids, nonprescription drugs, insect

## Improvements in Wastewater Treatment Reduces Endocrine Disruption in Fish

Signup

A team of scientists from the U.S. Geological Survey (USGS), the University of Colorado, and the City of Boulder, Colorado, demonstrated that improvements to the treatment process at a wastewater treatment facility (WWTF) reduced the level of endocrine disruption in fish exposed to wastewater effluent discharged from the facility. It is difficult to anticipate the effects that upgrading WWTF operations might have on stream ecosystems. In a recent article in *Environmental Science and Technology* the scientists report on a multiyear experiment to evaluate the impact on wastewater quality of a major ($45 million in cost) upgrade to the Boulder, Colorado, WWTF. The facility was converted from a biological filter plant with solids contact to an activated sludge plant.



### What They Did

In 2005 and 2007 the scientists established the water-quality conditions and level of fish endocrine disruption in test organisms before the upgrade. A similar set of investigations was conducted in 2008 and 2011 to document conditions after the upgrade. The two studies evaluated a wide variety of organic and inorganic contaminants

# How Do Process Upgrades for Nutrient Removal Effect CECs?

# Conventional Point Source (WW) Treatment

242 TOrC Evaluated

**Performance Indicator Selection**

*20 compounds*

**WW Processes:**

*HPO*

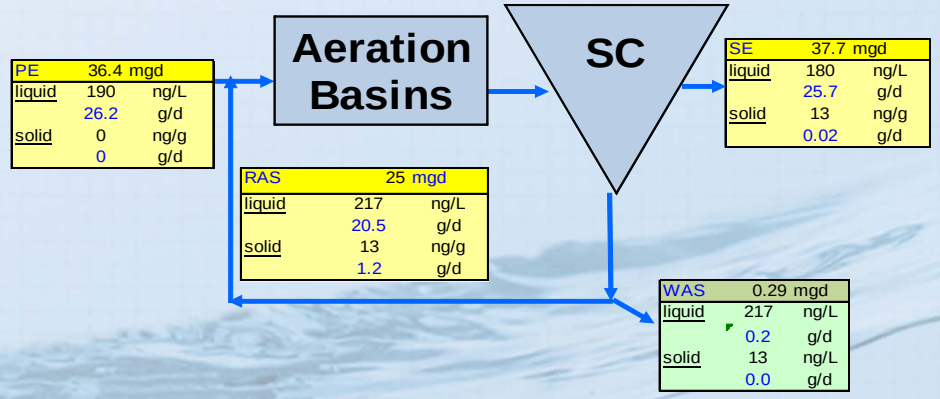
*MLE*

*BNR*

*MBR*

Operational Conditions:

*Temperature, Nitrification, SRT, HRT, N and P removal*

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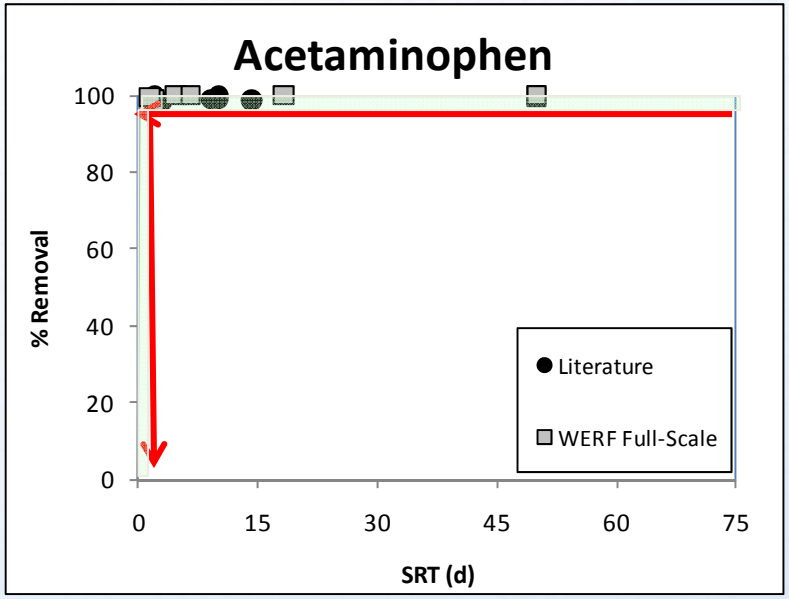
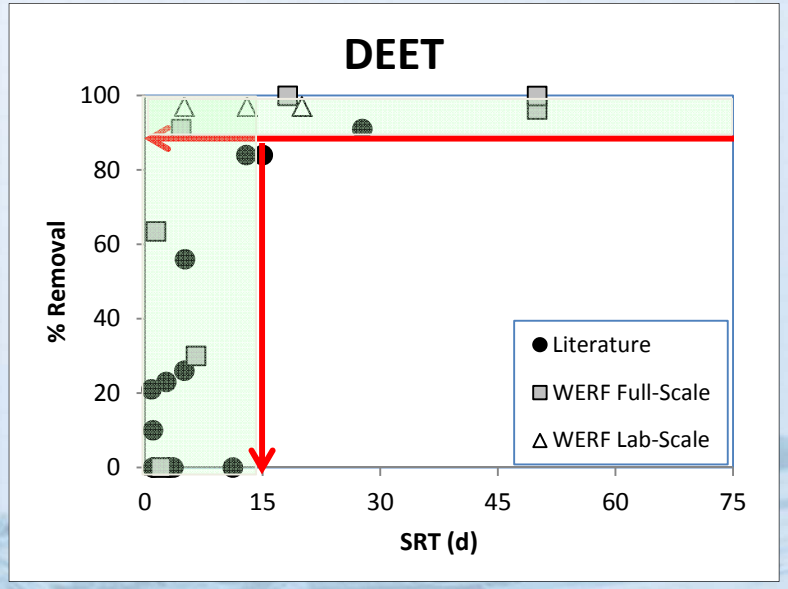
# How Much SRT is Required for TOrC Removal?




~ 80% TOrC Removal

| TOrC | SRT, days |
|---|---|
| Acetaminophen | 2 |
| Caffeine | 2 |
| Ibuprofen | 5 |
| Naproxen | 5 |
| Bisphenol A | 10 |
| Triclosan | 10 |
| DEET | 15 |
| Gemfibrozil | 15 |
| Atenolol | 15 |
| BHA | 15 |
| Iopromide | 15 |
| Cimetidine | 15 |
| Diphenhydramine | 20 |
| Benzophenone | 20 |
| Trimehoprim | 30 |

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# Indicator Matrix to Benchmark Treatment Performance

Faster transformation during secondary treatment

Higher sorption during secondary treatment

| | | Biotransformation ($K_b$, L/g-d) | | |
|---|---|---|---|---|
| | | **Recalcitrant <0.1** | **Moderate Slow 0.1-10** | **Rapid >10** |
| **Sorption (log $K_d$)** | **Low <2.5** | Carbamazepine<br>Meprobamate<br>Primidone<br>TCEP<br>Sucralose<br>**0-30 %**<br>**(typical 5%)** | DEET<br>Sulfamethoxazole<br>Gemfibrozil<br>Iopromide<br>**0-100 %**<br>**(typical 70-90%)** | Acetaminophen<br>Naproxen<br>Ibuprofen<br>Atenolol<br>**70-100 %**<br>**(typical 95%)** |
| | **Sorptive 2.5-3** | **0-60 %**<br>**(typical 20%)** | Cimetidine<br>Trimethoprim<br>**60-100** | Benzophenone<br>Diphenylbutylamine<br>Bisphenol A<br>**0-30 %**<br>**(typical 70%)** |
| | **Effective >3** | Triclocarban<br>**0-95%**<br>**(typical 50%)** | **n.a.** | Triclosan<br>Fluoxetine<br>**0-100 %** |

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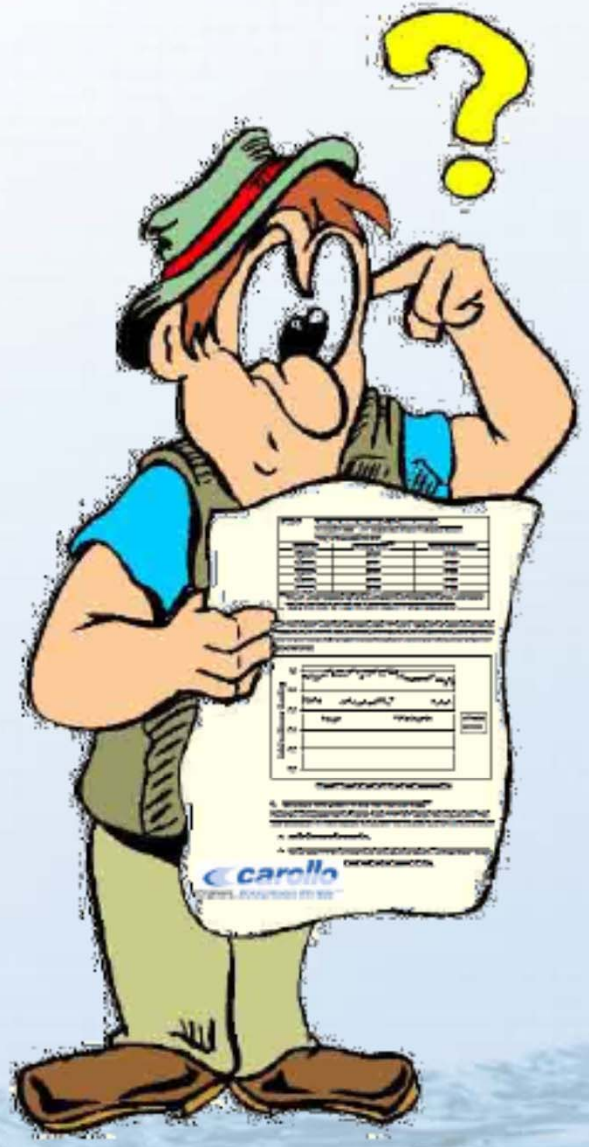
# Advanced Treatment Approaches for CEC Removal

| Drinking Water | Wastewater | Potable Reuse |
|---|---|---|
| • Ozone / BAF<br>• UVA/AOP<br>• GAC<br>• Membranes | • Ozone / BAF<br>• PAC / Filtration<br>• Membranes | • Soil Aquifer Treatment<br>• Bank Filtration<br>• Membranes<br>• UV/AOP or Ozone |

# Tool for Assessing CEC Removal in Reuse Schemes



# CEC in Biosolids

- Targeted National Sewage Sludge Survey (TNSSS) – 149 compounds
  - Antibiotics, drugs
  - Steroids, hormones
- Internal and External Review of Risk Assessment for 10 TNSSS compounds
- *WERF 2015 addl. investigations*
  - *PDBE*
  - *Azithromycin*
  - *Ciproflacin*

*Identified as "High priority chemicals"*

**10 TNSS Compounds**

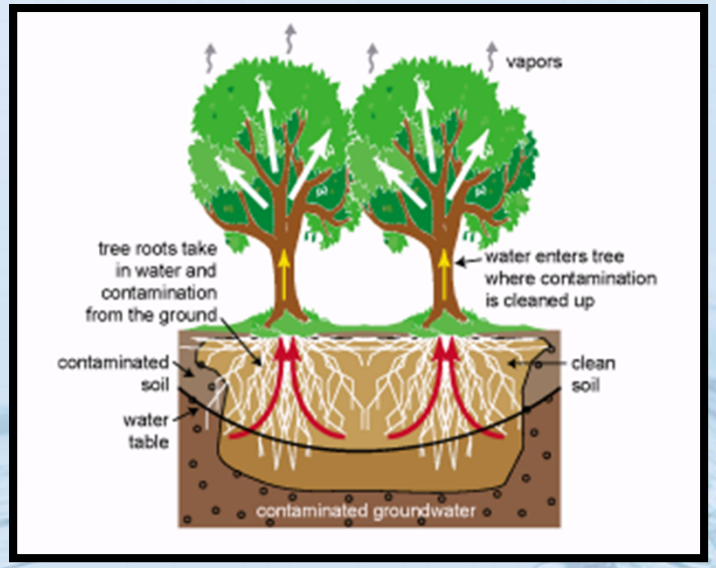
*1) Barium*
*2) Beryllium*
*3) Manganese*
*4) Molybdenum*
*5) Silver*
*6) 4-chlroraniline*
*7) Fluoranthene*
*8) Pyrene*
*9) Nitrate*
*10) Nitrite*

# CECs Concern for Agricultural Water Reuse?

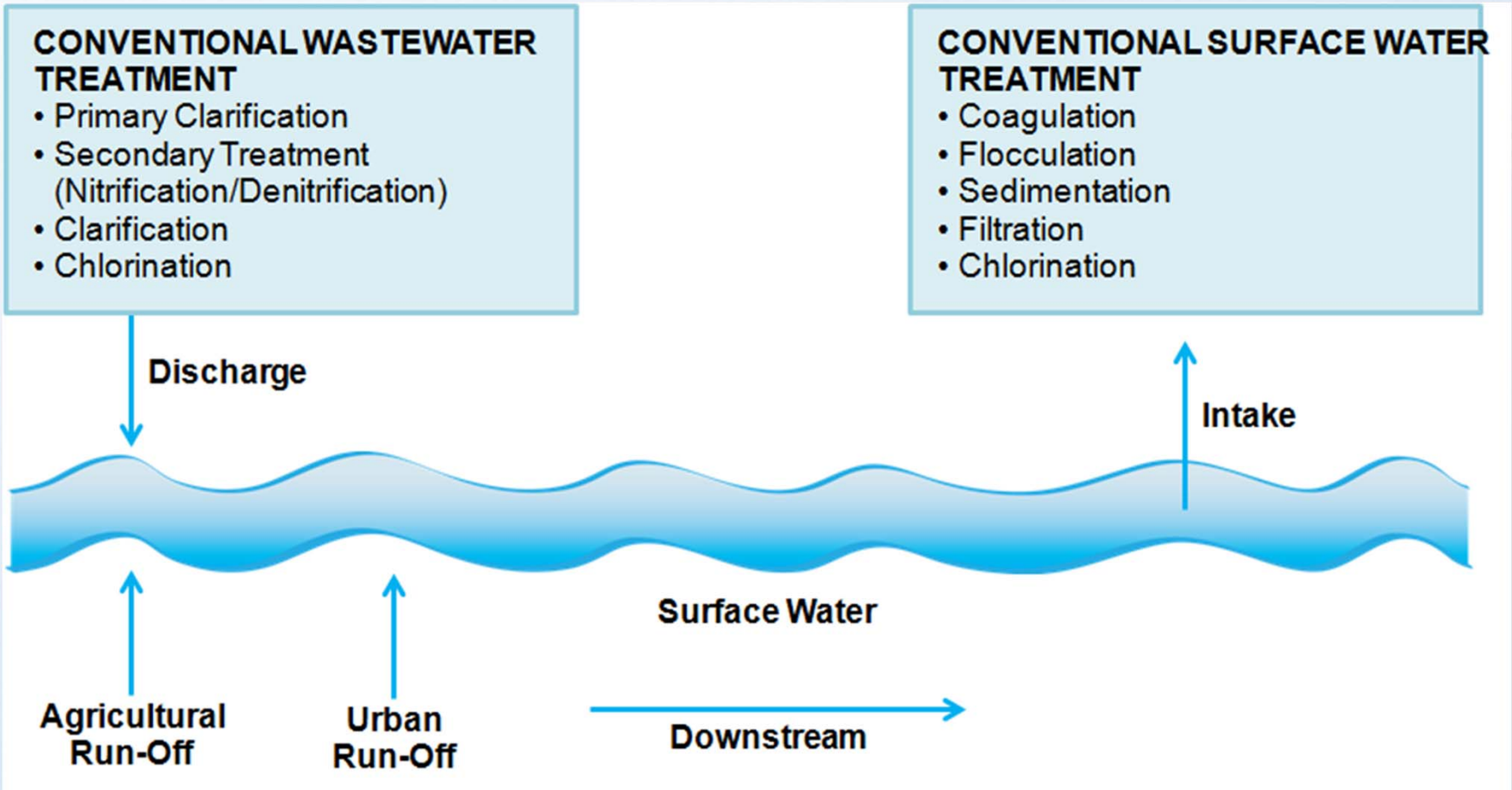
- Monterey, CA: 12,000 acres of vegetables (eaten raw) irrigated with reclaimed water for 14 years
- Osmotic barrier allows water and simple ions, but prevents uptake of organic compounds at typical concentrations in reclaimed water and biosolids

# Ongoing Research on CECs in Agricultural Water Reuse

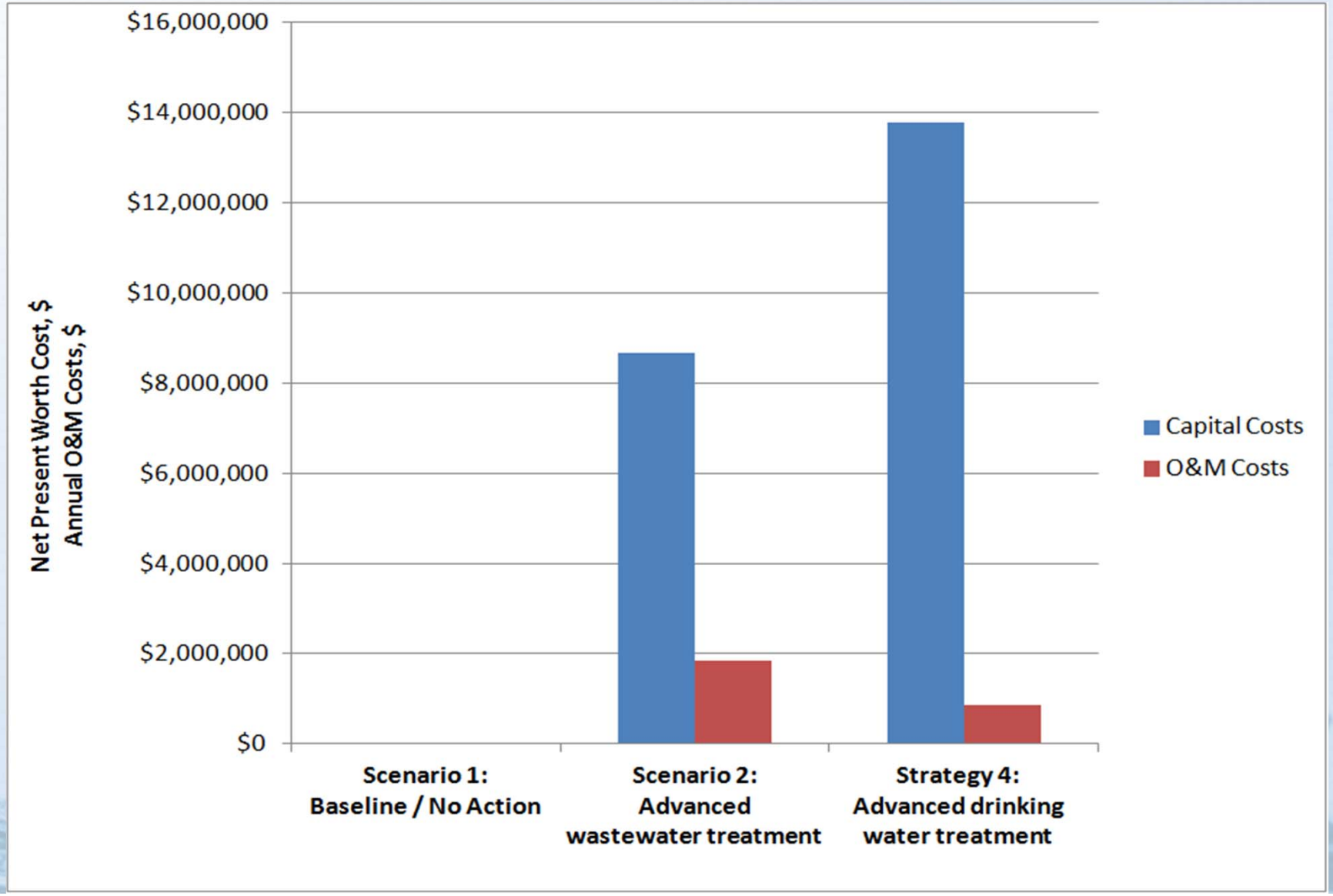
- Current research to investigate potential mechanisms of up uptake and bioaccumulation:
  - National Institute of Food and Agriculture Study (2011-2014): Bioaccumulation of CEC in Foodcrops from Reclaimed Water
    - Hydrophobic / hydrophilic compounds
    - Uptake in root, leaf, stem and fruit tissue
  - Transformation/ Degradation?
  - Risk to humans/ relevance?



# Where to Invest to Best Reduce CEC Risk?



# Triple Bottom Line Evaluation of a Realistic, Hypothetical Watershed Scenario



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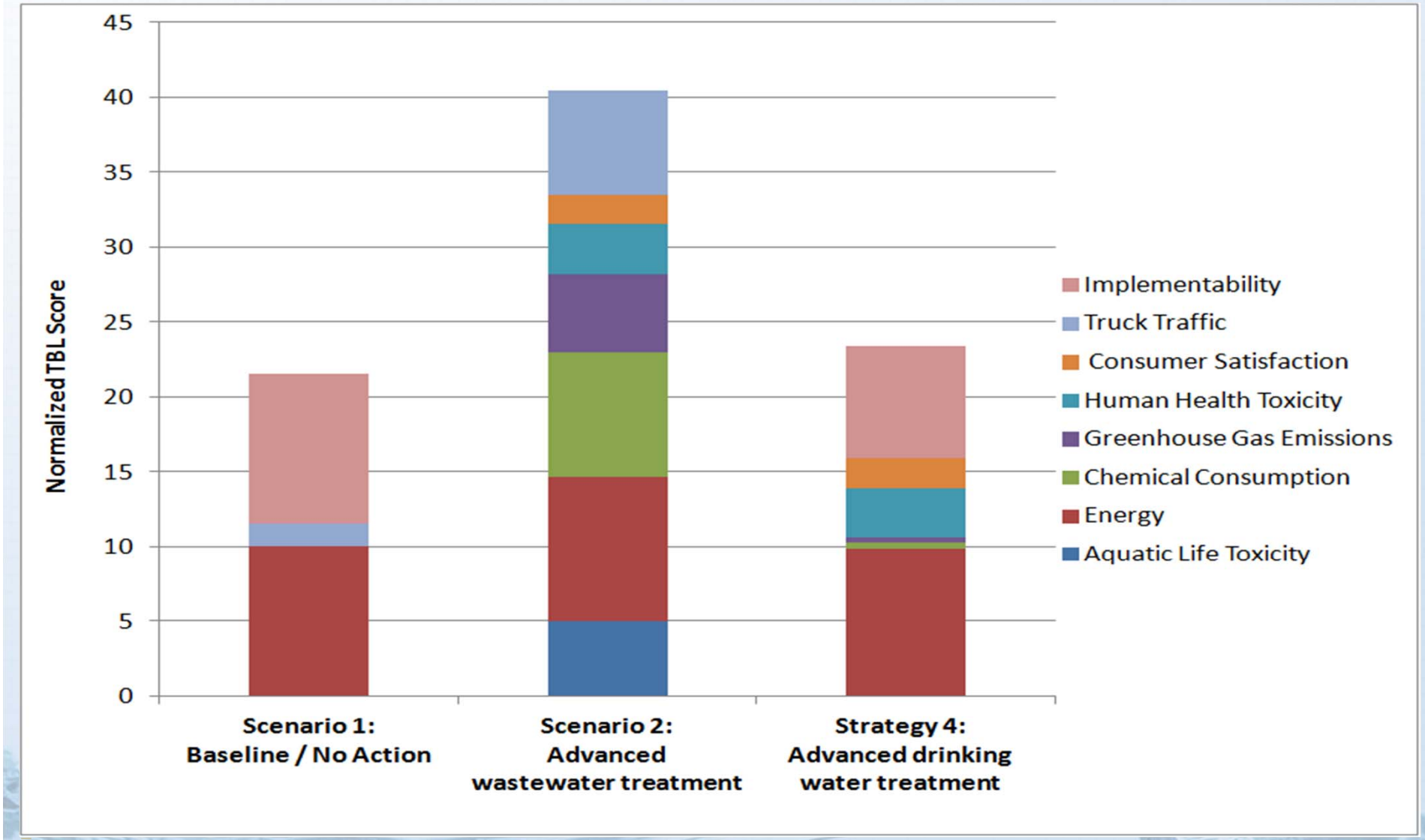

# What Does this Mean for Utilities Today

- “Wait-and-see-approach” or
- Drivers for proactive measures
  - Discharge into ecological sensitive watersheds
  - Near-term capital improvements, considerations of synergies for CEC removal
  - Long-term risk-based CIP
  - Public pressure
  - Multi-barrier approach in potable reuse systems
  - Specific demonstrated human health contaminant concerns

# Thank You!

CONTACT INFORMATION

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# Science is Still in Development

WHO 2012:

Given the low likelihood of human health risk, it is not considered necessary to implement routine monitoring programmes that are resource intensive and detract from other drinking-water concerns that are more important and more acute, particularly the threat of waterborne pathogens. However, where specific circumstances indicate a potential for elevated concentrations, screening values and targeted investigative monitoring could be considered.

http://apps.who.int/iris/bitstream/10665/44630/1/9789241502085_eng.pdf?ua=1

NACWA 2014:

NACWA, June 2014 to FDA

NACWA
A Clear Commitment to America's Waters

EXECUTIVE COMMITTEE
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Julius Ciaccia, Jr.
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Cleveland, OH

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Karen L. Pallansch
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Alexandria, VA

TREASURER
Adel H. Hagekhalil
Assistant Director
Bureau of Sanitation
City of Los Angeles
Los Angeles, CA

June 16, 2014

Division of Dockets Management (HFA-305)
Food and Drug Administration
5630 Fishers Lane, Room 1061
Rockville, MD 20852
Submitted via *www.regulations.gov*

**Re: Docket No. FDA-1975-N-0012, RIN 0910-AF69**

The National Association of Clean Water Agencies (NACWA) appreciates this opportunity to comment on the Food and Drug Administration's (FDA) proposed rule, *Safety and Effectiveness of Consumer Antiseptics; Topical Antimicrobial Drug Products for Over-the-Counter Human Use; Proposed Amendment of the Tentative Final Monograph;*

consumer antiseptic washes as safe and effective. Due to concerns about the impacts of antiseptic chemicals on the wastewater treatment process and on the environment, NACWA members support restrictions of the use of antiseptics in consumer products and the FDA's proposal to require additional data about these chemicals.

drain and directly into the sewer system. Since wastewater treatment utilities were not designed to remove triclosan and other antiseptics from wastewater, regulation of these chemicals by the U.S. Environmental Protection Agency (EPA) and the FDA at their source is the most practical means of controlling their discharge into wastewater and preventing adverse impacts on wastewater utilities, human health, or the environment.

# CEC Terminology can be Confusing

**Contaminants of Emerging Concern**

**Trace Organic Compounds**

**Microconstituents**
**Emerging Contaminants**
**Nano Particles**

## Commonalities

1. Natural and manmade
2. Unregulated
3. Human and eco health impacts not yet fully understood

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