Recommendations: Constituents of Emerging Concern (CEC) Monitoring for Recycled Water

State Water Resources Control Board

December 15, 2010

Public Hearing

How did the SWRCB Handle CECs in the Recycled Water Policy?

- Regulatory requirements need to be based on best available peer-reviewed science
- State of knowledge regarding CECs is incomplete
- Need for an advisory panel to guide future actions relating to CECs
- Composed of experts in six relevant fields
- To be convened within 90 days of Policy adoption
- Respond to charge questions and document in report to SWRCB

Panel Selection Process

- SWRCB contracted with the Southern California Coastal Water Research Project (SCCWRP) to select and manage panel
- SCCWRP enlisted Stakeholder Advisory Group to guide panel member selection
- Panel of six experts recruited; convened May 4, 2009

Panel Members

- **Dr. Paul Anderson**
  - Human Health Toxicologist
  - Arcadis-US, Boston University
- **Dr. Nancy Denslow**
  - Biochemist
  - University of Florida
- **Dr. Jörg Drewes**
  - Civil Engineer
  - Colorado School of Mines
- **Dr. Adam Olivieri**
  - Risk Assessor
  - EOA Incorporated
- **Dr. Daniel Schlenk**
  - Environmental Toxicologist
  - UC Riverside
- **Dr. Shane Snyder**
  - Analytical Chemist
  - Total Environmental Solutions, Inc, Univ. Arizona

PROCESS & PHILOSOPHY

- **Open and transparent process**
  - Panel member selection
  - Meeting agendas & information exchange
  - Comments and feedback
- **Public commentary & panel report out at each meeting**
- **Stakeholder advisory group with diverse interests**
  - Water resource & supply community
  - Public interest groups
  - State agencies
- **Recommendations to be science-based**

STATE RECYCLED WATER POLICY

- What are the appropriate constituents to be monitored, including analytical methods and MDLs?
- What is the known toxicological information for the above constituents?
- Would the above list change based on level of treatment and use? If so, how?
- What are possible indicators that represent a suite of CECs?
- What levels of CECs should trigger enhanced monitoring of CECs in recycled water, groundwater and/or surface waters?

SCHEDULE

- **April 1, 2009 -- SCCWRP contracted to manage Panel**
  - establish Stakeholders Advisory Group
  - identify & select panel candidates
- **May 5, 2009 – CEC Science Advisory Panel convened**
- **September 2009 – Kickoff Meeting (#1)**
  - Background & stakeholder perspectives presented
- **January, February 2010 -- Meetings #2 & #3**
  - Panel working meetings to address charge questions

SCHEDULE

- **April 16, 2010 -- Draft report released**
  - 30 day comment period
- **May 2010 – Final Meeting (#4)**
  - Panel responds to written comments
  - Outlines revisions to be made in final report
- **June 25, 2010 -- final report submitted to SWRCB Staff**
- **Dec 15, 2010 – Staff recommendations to SWRCB**

SWRCB Staff Report on Constituents of Emerging Concern: Recommendations from the State of California Science Advisory Panel

Jörg Drewes (Chair), Paul Anderson,

Nancy Denslow, Adam Olivieri,

Daniel Schlenk, Shane Snyder

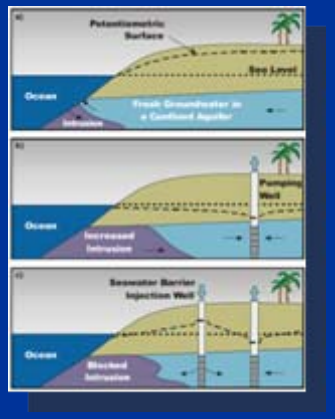
December 15, 2010

CALIFORNIA RECYCLED WATER POLICY

- **Focus on Three Re-Use Practices in which CECs may represent a potential threat to human and aquatic health**

1. Indirect potable reuse via surface spreading of recycled water

2. Indirect potable reuse via subsurface injection of recycled water into a potable aquifer



3. Urban landscape irrigation with recycled water

THE PANEL'S APPROACH TO ITS CHARGE

1. **Develop a universal framework the State could use to select current and future CECs for recycled water monitoring programs**

   - A "tool" based on best-available science to prioritize CECs now and in the future

2. **Apply framework to recycled water projects state-wide**

   - Preliminary CEC monitoring list ("what" to monitor)

3. **Develop guidance regarding monitoring and interpretation**

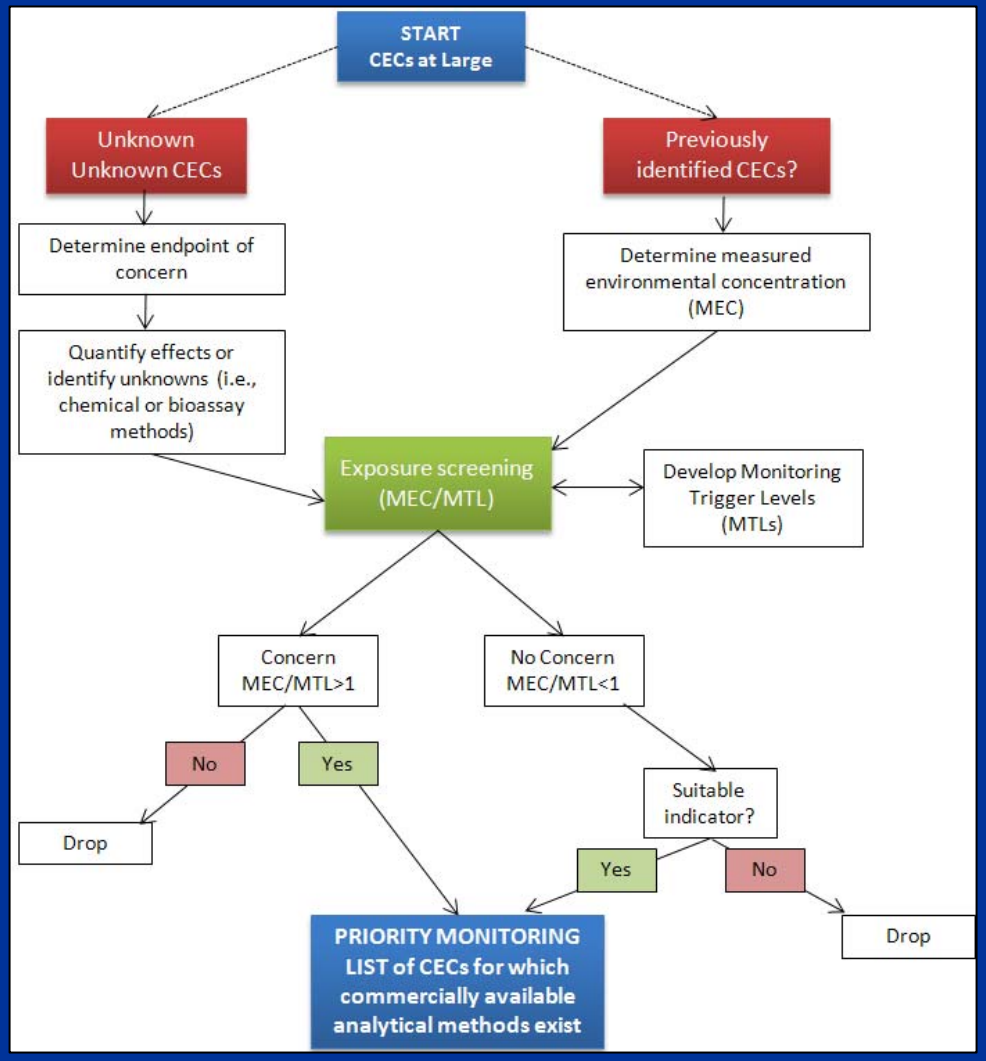
   - How, where and when to monitor; and how to respond to results

4. **Recommend future activities**

   - Research, support tools and audits to improve & refine the process

HOW THE DECISION MAKING FRAMEWORK WORKS?

- **Step 1: Measure CEC concentration in recycled water**
  - Many utilities provide data through voluntary/investigative monitoring
- **Step 2: Determine allowable concentration that is protective of human health**
- **Step 3: Combine Steps 1 and 2 (measured / allowable)**
  - If ratio is < 1, no concern
  - If ratio is ≥ 1, add to candidate list



HOW THE FRAMEWORK WAS APPLIED

- **Panel provided two sets of recommendations**
  - Groundwater recharge (indirect potable reuse)
  - Title 22 landscape irrigation (non-potable)

- **Which CECs were considered in the selection?**
  - Utilized comprehensive national CEC database (EPA's "CCL3")
    - Considered > 26,000 chemicals, pared to 106 on final CCL3
  - Also used actual CEC monitoring data from several CA utilities
    - 8 CCL3 chemicals and 43 non-CCL3 chemicals
    - included chemicals on Cal UCMR and notification substances

- **What was required for the final selection?**
  - Toxicological data available from peer-reviewed sources
  - Monitoring data from California (conservative estimates)

HOW TO TARGET THE PROPER NUMBER OF CHEMICALS? – IS MEASURING MORE ALWAYS BETTER?

- **How to assess whether a process can remove CECs to safe levels?**
  - Select chemicals that are toxicologically relevant at low concentrations and monitor removal

    => "health-based indicator" chemical

  - Select chemicals with different physicochemical properties and structures and demonstrate that they can be removed by a particular water treatment process

    => "performance-based indicator" chemical

    => Certain "performance-based indicators" correlate with bulk parameters ("surrogates"), which are much easier to measure

  - For both groups, selected indicator chemicals should represent multiple CEC source classes (pharmaceuticals, personal care products, food additives, hormones)

CEC LIST FOR GROUNDWATER RECHARGE

- **4 health-based and 5 performance-based indicators identified**

Reuse Practice	Health-based Indicator	MRL (ng/L)	Performance-based Indicator	Expected Removal[8]	MRL (ng/L)	Surrogate	Method	Expected Removal[8]
Groundwater Recharge SAT	17β-estradiol[1]	1	Δgemfibrozil[5]	>90%	10	Δammonia	SM	>90%
	Triclosan[2]	50	ΔDEET[6]	>90%	10	Δnitrate	SM	>30%
	Caffeine[3]	50	ΔCaffeine[3]	>90%	50	ΔDOC	SM	>30%
	NDMA[4]	2	Δiopromide[5]	>90%	50	ΔUVA	SM	>30%
			ΔSucralose[7]	<25%	100			
Direct Injection	17β-estradiol[1]	1	ΔDEET	>90%	10	Δconductivity	SM	>90%
	Triclosan[2]	50	ΔSucralose	>90%	100	ΔDOC	SM	>90%
	Caffeine[3]	50	ΔNDMA	25-50%	2			
	NDMA[4]	2	ΔCaffeine	>90%	50			

CEC LIST FOR LANDSCAPE IRRIGATION (TITLE 22)

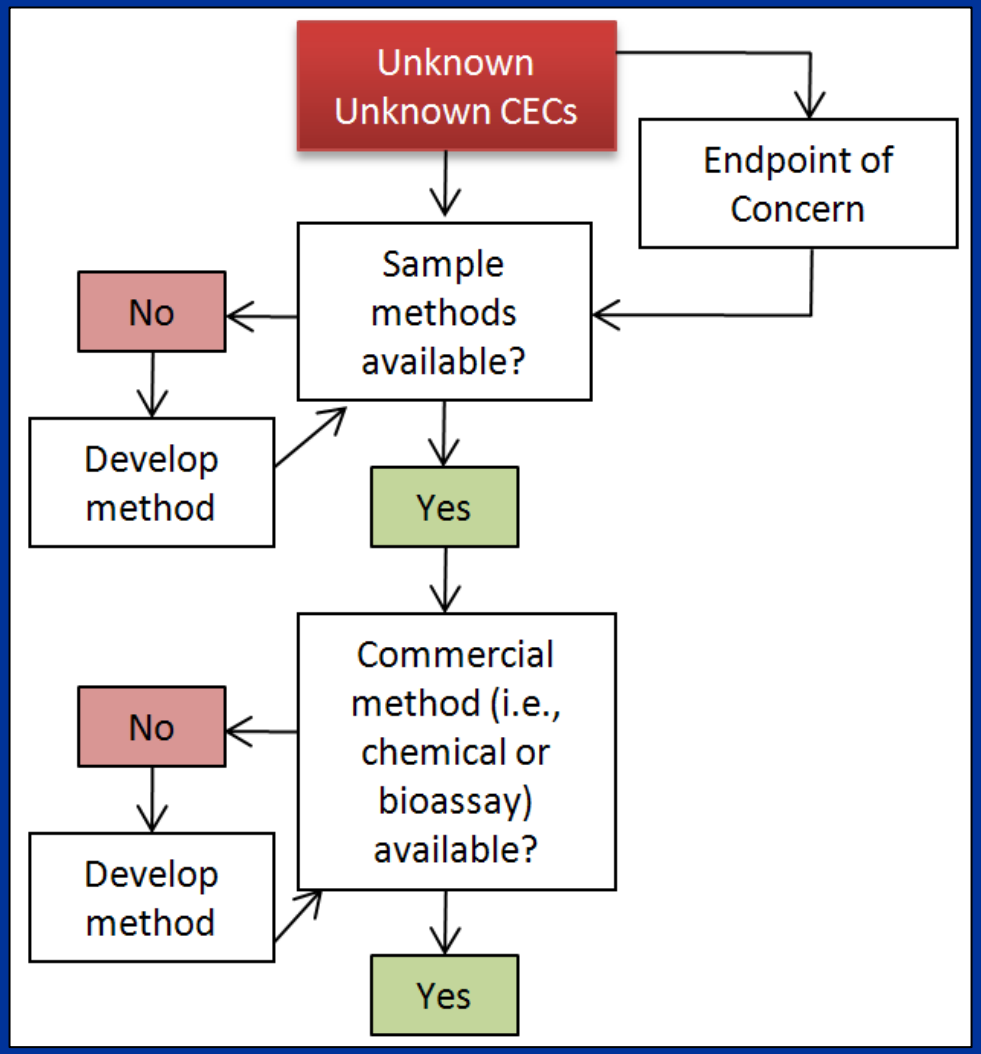
- No CECs identified based on health risk
- Human consumption (incidental) of recycled water in this scenario is very low
- Surrogate parameters are best way to assess Title 22 recycled water quality
- The parameters selected were turbidity, chlorine residual, and total coliform bacteria

WERE ANTIMICROBIALS AND ANTIBIOTIC RESISTANCE CONSIDERED BY THE EXPERT PANEL?

- Antimicrobials were considered by the Panel
- Since occurrence of antimicrobials in recycled water is expected to be very low, they would have an insignificant impact on any risk associated with reuse practices of interest
- Antibiotic resistant bacteria were NOT considered by the Panel since microorganisms were outside the Panel's charge
- However, the Panel acknowledged that antibiotic resistant genes have been reported in groundwater, drinking water and wastewater and therefore represent a national problem that requires further study. It is the view of the Panel that the specific reuse practices of interest here do not cause the problem nor add to it at the present time

WHAT ABOUT THE UNKNOWN CHEMICALS THAT MIGHT BE PRESENT IN RECYCLED WATER?

- The Panel recommended the use of bioanalytical screening tools to overcome limitations associated with measuring individual chemicals
- However, the Panel also acknowledged that additional research is needed to develop these methods



RECOMMENDED FUTURE ACTIVITIES

- **Improving the database for CEC monitoring information**
  - Conduct comprehensive review of peer-reviewed literature and occurrence studies *outside California* to populate a recycled water database for CECs
  - Use that database as a basis to execute the selection framework
- **Development of bioanalytical screening techniques**
  - Develop techniques that can address “unknown” chemicals potentially present in recycled water
- **Programmatic support to manage the process**
  - Develop a process to manage data & apply framework
  - Perform independent audit of Panel’s initial recommendations
  - Revisit monitoring recommendations every 3-5 years

CONCLUDING REMARKS

- **Given the multiple dimensions of CECs in recycled water, we believe the State is served best by following a science-based, transparent process**

Recommendations: Constituents of Emerging Concern (CEC) Monitoring for Recycled Water

Gary Dickenson, Engineering Geologist

Division of Water Quality

State Water Resources Control Board

December 15, 2010

Public Hearing

DWQ Staff Recommendations

***Staff Report – Constituents of Emerging Concern (CEC) Monitoring for Recycled Water*, 11/8/10**

<u>Relied on</u>:

- **CEC Advisory Panel report: *Monitoring Strategies for Chemicals of Emerging Concern in Recycled Water*, June 25, 2010**

- **Recommendations from CDPH**

DWQ Staff Recommendations

DWQ Staff concurs with the Panel's presented approach and CDPH recommendations

- Screening framework
- CECs and surrogate parameters – Panel and CDPH
- Monitoring locations and frequency
- Quality assurance and control (QA/QC)
- Tiers and thresholds for interpreting health-based CEC results
- Additional research
  - Bioanalytical screening techniques

CEC Screening Framework

Conceptual framework for determining which CECs to monitor

- Compile environmental concentrations (e.g., measured environmental concentration [MEC]) of CECs in recycled water;
- Develop monitor triggering levels (MTLs) for CECs based on toxicological relevance;
- CECs with a MEC/MTL ratio greater than “1” are prioritized for monitoring (“health-based CECs”)
- Reliable analytical method for detecting CEC

CEC Screening Framework
(cont.)

Processes used to select MTLs

- Selected initial monitor triggering levels (MTLs) from select agencies or study established drinking water benchmarks;
- Subsequent MTLs should be derived as follows:
  - MTL = [ADI x 60 kg x RSC]/[2 L/day]

    ADI - allowable daily intakes
    RSC - relative source contribution

Health-based CECs selected using the screening approach

Groundwater recharge/reuse projects

- 17beta-estradiol: Steroid hormone
- Caffeine: Stimulant
- N-Nitrosodimethylamine (NDMA): Disinfection by-product
- Triclosan: Antimicrobial

Landscape irrigation

- No CECs identified by the screening process

CECs Recommended by CDPH

Bisphenol A (BPA)	N-Nitrosodiethyamine (NDEA)
Boron	N-Nitrosodimethylamine (NDMA)
Carbamazepine	N-Nitrosodi-n-propylamine (NDPA)
Chlorate	N-Nitrosodiphenylamine
Chromium, hexavalent (CrVI)	N-Nitrosopyrrolidine (NPYR)
Diazinon	1,2,3-Trichloropropane (1,2,3-TCP)
1,4-Dioxane	Tris(2-chloroethyl) phosphate (TCEP)
Naphthalene	Vanadium

Performance Indicator CECs

Staff concurs with the Panel's selection of performance indictor CECs

- Caffeine: Stimulant
- NDMA: Disinfection by-product
- Gemfibrozil: Pharmaceutical
- Iopromide: Pharmaceutical
- N,N-Diethyl-meta-toluamide (DEET): Personal care
- Sucralose: Food additive

Indicator and Surrogate Parameters

Treatment process performance indictors and surrogates

- An indicator compound is an individual CEC that represents certain physicochemical and biodegradable characteristics of a family of trace organic constituents.
- A surrogate parameter is a parameter used to measure the performance of individual unit processes (often in real-time) or operations in removing trace organic compounds and/or assuring disinfection.

Performance Surrogates

Selected performance indictor surrogates

Groundwater recharge/reuse

- Ammonia, dissolved organic carbon, nitrate, conductivity, and UV absorbance

Landscape irrigation

- Chlorine residual, total coliform, and turbidity

Monitoring Locations

Groundwater recharge/reuse – Surface spreading area

- Final effluent after tertiary treatment and prior to release to the spreading basin
- At monitoring wells representing the uppermost groundwater and/or from shallow lysimeter wells underlying the spreading basin; following percolation threw the unsaturated soil column
- At down-gradient well(s) representing the potable source water prior to the potable water treatment plant

Monitoring Locations (cont.)

Groundwater recharge/reuse – Injection

- Between filtration and membrane (reverse osmosis) treatment processes
- Between membrane and advanced oxidation treatment
- Final effluent after advanced oxidation and prior to injection into an aquifer

Landscape Irrigation

- After final treatment prior to distribution

Monitoring Frequency

Initial assessment

- CECs - At a minimum, quarterly analysis for the first year
- Surrogate parameters - Daily or Weekly

Baseline operations

- CECs - Twice per year for a minimum of three years
- Surrogate parameters - Daily or Weekly

Following baseline monitoring, re-evaluate monitoring program requirements

Monitoring Results and Response

Interpreting health-based CEC monitoring results and response

- Five tiers of thresholds and response actions
  - Tier I - If no more than 25 percent of the sample results (i.e., MECs) for a health-based CEC exceed a MEC/MTL ratio of 0.1, then the CEC should be considered for removal from the monitoring program.
  - Tier II - MEC/MLT $\geq$ 1 and < 10, check the data and continue to monitor

Monitoring Results and Response (cont.)

- Tier III - MEC/MLT > 10 and < 100, resample immediately, analyze to confirm the MEC, and continue to monitor
- Tier IV - MEC/MLT > 100 and < 1,000, same as above and implement a source identification program. Also, monitoring at a point in the distribution system closer to the point of exposure to confirm that attenuation of the CEC is occurring subsequent to the monitoring location and to confirm the magnitude of assumed safety factors associated with removal efficiency.

Monitoring Results and Response (cont.)

- Tier V - MEC/MTL > 1,000, same as above plus immediately confer with the CDPH and the Regional Water Board to determine the required response action.

Additional Research

The CEC Panel provided recommendations for additional research. Staff concurred with the following approach:

- Encourage development of bioanalytical screening techniques that include CECs currently not identified but potentially present in recycled water (“unknown” chemicals). Develop appropriate trigger levels for these bioanalytical screening techniques that correspond to a response posing a concern from a human health standpoint.

PUBLIC TESTIMONY

Significant Issues and Next Steps

Vicky Whitney
Deputy Director
Division of Water Quality

Significant Issues

- **Approve the Panel's CEC screening framework approach?**
- **Is it appropriate to include the CDPH recommended constituents for monitoring?**
- **Regional Water Boards monitoring:**
  - Should the Regional Water Boards be required to use monitoring program recommended in Staff Report, even if they already have required CEC monitoring?
  - For additional CECs beyond the Staff Report recommendations, require the use of the "framework"?
  - Role for OEHHA in use of "framework" for additional CECs?

Significant Issues

- **To address “unknown unknowns”:**
  - Continue with chemical-by-chemical approach? (Panel Recommendations 1-5)
  - Instead, pursue bioanalytical methods? (Panel Recommendation 6)

- **Funding of bioanalytical approach**

Next Steps

- Staff revise Recycled Water Policy in accordance with Board Direction
- Circulate documents for required 60-day notice to Regional Water Boards
- Bring to State Water Board for consideration in Summer, 2011