

# **Evaluation Monitoring vs Chemical-Constituent Monitoring: Chemical Concentrations vs Chemical Impacts**

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## ABSTRACT

By tradition, water quality monitoring has focused on compliance monitoring where the concentrations of a variety of chemical constituents are measured in wastewater discharges for stormwater runoff and the concentrations found are compared to water quality standards. This approach provides little in the way of reliable information on the real water quality use impairments associated with chemical constituents and pathogen indicator organisms in wastewater discharges and stormwater runoff. There is growing recognition that rather than focusing on chemical constituent concentrations, the monitoring program should be focusing on chemical impacts on the beneficial uses of waterbodies.

Drs. G. Fred Lee and Anne Jones- Lee have developed "Evaluation Monitoring" as an alternative to conventional monitoring where the emphasis is on developing a watershed- based, consensus approach of a waterbody's water quality stakeholders that focuses on first defining the real, significant water quality use impairments that are occurring in a waterbody. Once these have been defined, then the Evaluation Monitoring program focuses on determining the cause of these use impairments, including the specific constituents responsible for such impairments as aquatic life toxicity, the source of the toxic- available forms of the constituents that are causing use impairments and develops a watershed- based, stakeholder consensus on the appropriate approach to take in managing the use impairments. Typically for urban area and highway stormwater runoff, the use impairments focus on source control of the constituents.

Dr. Lee summarizes some of the problems with conventional water quality monitoring and provides an overview of Evaluation Monitoring using the results that have been attained over the past four years in an Evaluation Monitoring Demonstration Project that has been conducted in the Upper Newport Bay watershed in Orange County, California. This presentation discusses some of the new frontiers in water quality monitoring and management that need to be addressed in order to cost- effectively use public and private funds to manage real, significant water quality problems without unnecessary expenditures for chemical constituents control.

Additional information on the deficiencies in current chemical concentration- based water quality monitoring, and the development of Evaluation Monitoring programs is available from Dr. Lee's web site (<http://members.aol.com/gfredlee/gfl.htm>).

## **Biographical Sketches**

**Drs. G. Fred Lee, PE, DEE and Anne Jones Lee**

Dr. G. Fred Lee is President, and Dr. Anne Jones-Lee is Vice President, of G. Fred Lee & Associates, an environmental consulting firm located in El Macero, California. Dr. Lee obtained a Master of Science degree in Public Health from the University of North Carolina and a PhD in environmental engineering from Harvard University in 1960. For 30 years, he held university graduate-level teaching and research positions. During that time, he conducted over \$5 million in research and published over 500 papers and reports devoted to water supply water quality, water and wastewater treatment, water pollution control and solid and hazardous waste impact evaluation and management. In 1989 he retired from university teaching and expanded the part-time consulting that he had been doing since the 1960s into a full-time activity.

Dr. Anne Jones-Lee obtained a bachelor of science degree from Southern Methodist University in the biological sciences and masters and PhD degrees from the University of Texas at Dallas in environmental sciences. For eleven years she held university graduate-level teaching and research positions.

# **Evaluation Monitoring vs Chemical- Constituent Monitoring**

## ***Chemical Concentrations vs Chemical Impacts***

G. Fred Lee, PhD, DEE & Anne Jones-Lee, PhD  
G. Fred Lee & Associates  
El Macero, CA

Current So-Called “Water Quality Monitoring” Largely Waste of Public & Private Funds WHY?

Provides Unreliable Information on Real Water Quality Issues

Alternative Approach: ***Evaluation Monitoring***

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Presented at CA Water Environment Association Training Seminar, “*Recent Advances in Receiving Water Monitoring*,” Anaheim, CA, February 1999

# “Water Quality”

## What It IS and What It Is NOT

**IS:** Character of Water Relative to Designated Beneficial Uses

**IS NOT:** a List of Concentrations of Chemical Constituents & Biological Data Compared to Numeric Standards

### Example

<u>Constituent</u>	<u>Concentration</u>	<u>Exceed WQ Std?</u>
Cu	38 µg/L	+
Zn	49 µg/L	-
Pb	32 µg/L	+
PCB	5 ng/L	+
Hg	7 ng/L	?
Cl <sup>-</sup>	39 mg/L	-
<i>Ceriodaphnia</i> toxicity	7 TUa	+





**Cannot Evaluate Water Quality / Use-Impairment from This Type of Data**

# Compliance Monitoring

## **Objective :**

- Determine If Concentrations of Constituents in an NPDES-Permitted Discharge Exceed Water Quality Standards or Discharge Limits

Adopted by US EPA in Early 1980's

- Supported by Environmental Activist Groups
- Mechanical - Easy to Administer

## **Problem:** Often Technically Invalid

- Leads to Over-Regulation of Regulated Constituents (Those with Water Quality Standards)
- Under-Regulation of Constituents with No Water Quality Standards

# US Water Pollution Control Program Misdirected

- Focus on Concentrations/Loads of Chemical Constituents
  - Exceedance of Worst-Case-Based Water Quality Standards
  - Makes Any Bureaucrat, Environmental Group Attorney, NPDES Water Pollution Control Program Manager, Consultant, a “Water Quality Expert”
  - Does Not Require Understanding of Science & Engineering Fundamentals of Water Quality Assessment & Management

BUT...



# US Water Pollution Control Program Misdirected

BUT . . .

Everyone Is Happy



- **Agency Head** Achieves “Compliance” with Water Quality Standards
- **NPDES Discharge Managers** Get Regulators Off Their Backs
- **Environmental Groups** Get Litigation Settlement & Support for Attorneys
- **Testing Laboratory** Makes Money Conducting Analyses
- **Consultants** Have Billable Time

# US Water Pollution Control Program Misdirected

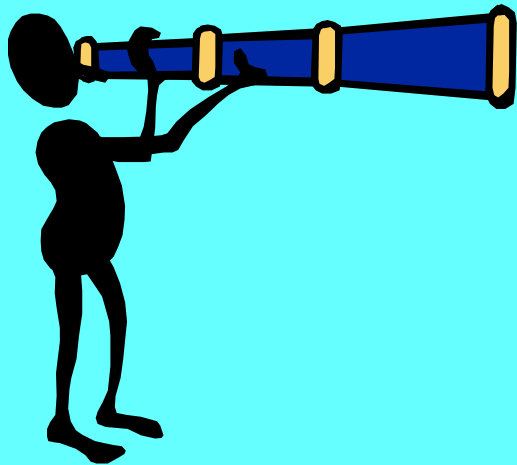
What about the Public?



- Over-Regulated  
Wastes Public Funds, Jobs
- Inadequate Regulation of True  
Problem Areas

# Step Back . . .

## Why Are We Monitoring?



- What Do We (the Public) Want to Obtain from Monitoring?
- How Should We Spend Public Funds for Monitoring & Water Pollution Control?

# What Is Water Quality?

- Clean Water Act - Character of Water Relative to Designated Beneficial Uses
  - Focus on Impacts of Chemical on Beneficial Uses
  - Not Control of Chemical Concentrations
- Chemical Concentration Approach Has Misled Public on Water Quality “Impacts”
  - Urban Stormwater Runoff as Cause of Water Quality Impairment
- Copper **Concentration** vs Copper **Toxicity**
  - Toxicity - Yes or No
  - If Yes, Is There a Beneficial-Use Impairment?



# chemistry

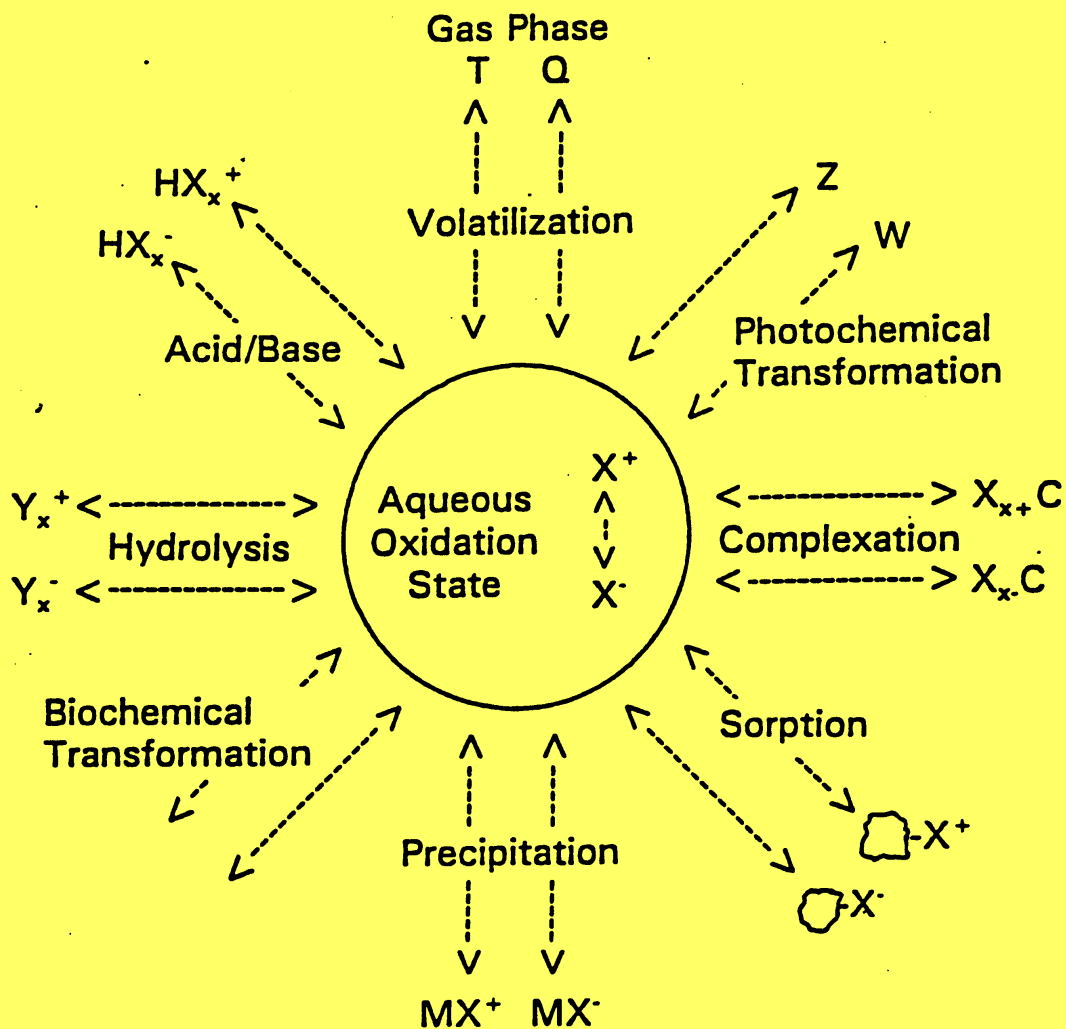


***“It’s Why I Became a Biologist... an Engineer... an Attorney”***

# Chemistry

- ***Kinetics & Thermodynamics*** of Chemical Reactions That Determine the Distribution of Chemical Species
  - Relationship between Total Concentrations and Toxicity/Availability
- **Not** Results of Chemical Analyses - Concentrations of List of Chemicals
- Aquatic Chemistry Key to Technically Valid, Cost-Effective, Environmentally Protective Water Quality Management

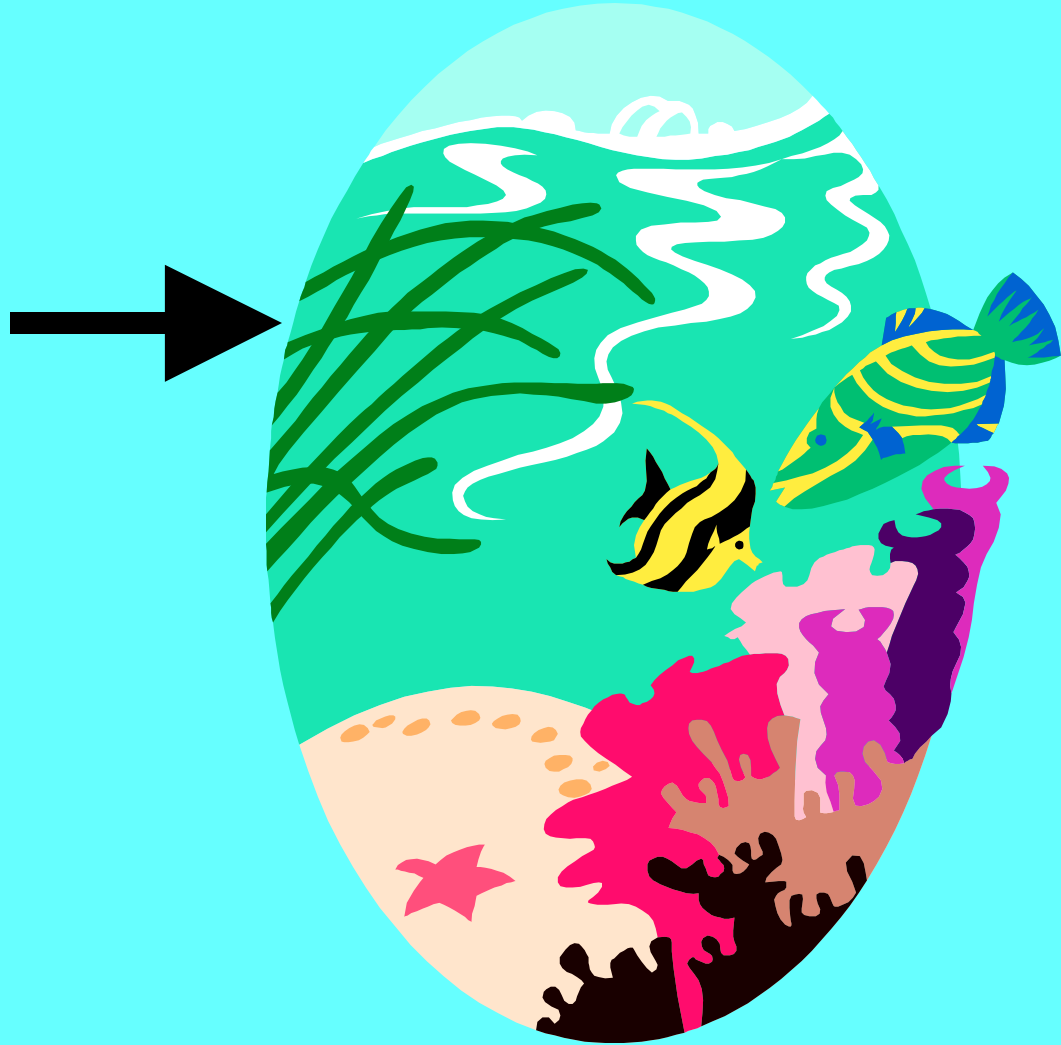
# Aquatic Chemistry of Chemical Constituents



Distribution among Species Depends on Kinetics & Thermodynamics of Reactions in the Particular Aquatic System

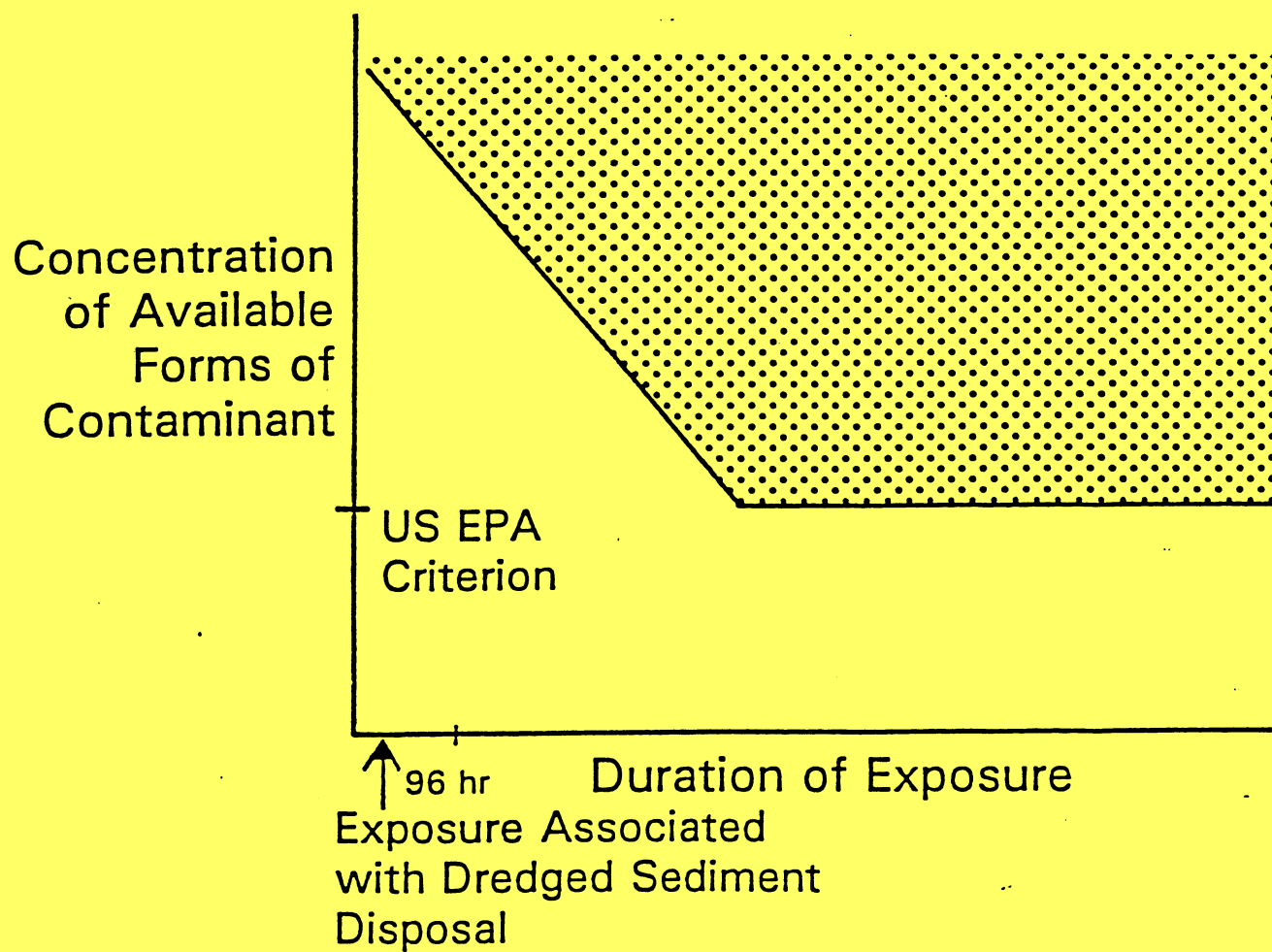
Each Chemical Species Has Its Own Toxicity Characteristics

- Many Forms Are Non-Toxic





# Figure C-1 Aquatic Toxicology



# Current Chemical-Concentration-Based Approach

- Ignores How Chemicals Impact Water Quality
- Large Amounts of Money Spent on Chemical-Constituent “Water Quality” Monitoring
- Water Quality Issues of Concern to Public
  - Copper **Toxicity** - Not Copper Concentration
  - Lead **Toxicity** - Not Lead Concentration
  - Mercury **Bioaccumulation** - Not Mercury Concentration
  - PCB **Bioaccumulation** - Not PCB Concentration
  - Excessive **Algae** - Not Nitrate Concentration

# Current Chemical-Concentration-Based Approach

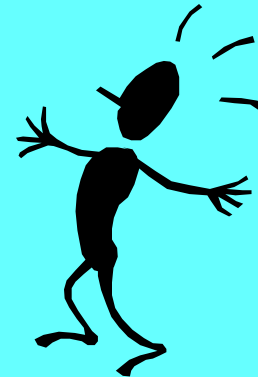
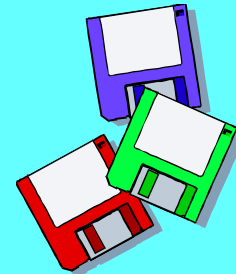
- “US EPA Current Water Pollution Control Program Highly Successful”



“Success” of Monitoring Program Façade

“File Cabinet Fodder” Typically of Limited Value

- “Protective of Environment”?
  - Overly Protective and
  - Under-Protective (OP Pesticides)



# Current Chemical-Concentration-Based Approach

- Short-Changes the Public into Believing That the Current US EPA Water Pollution Control Approach Is Technically Valid & Cost-Effective
  - Far From It
- Must Change Approach



# Alternative Approach for Water Quality Management

- Focus on **Impacts** of Chemical Contaminants on Beneficial Uses of Waterbody
  - Domestic Water Supply
  - Fish & Aquatic Life
  - Contact Recreation
  - Non-Contact Recreation
  - Agricultural Water Supply
  - Cooling Water
  - Navigation
  - Wastewater Disposal
- Is the Use Adversely Affected?
  - Nature of Impact • Cause • Significant Sources
- Toxicity - Toxic Forms / Duration of Exposure



# What Needs to Be Monitored for Evaluation of Water Quality?

- Chemical Concentrations - no
- Toxicity Magnitude - yes
- Duration of Exposure - yes

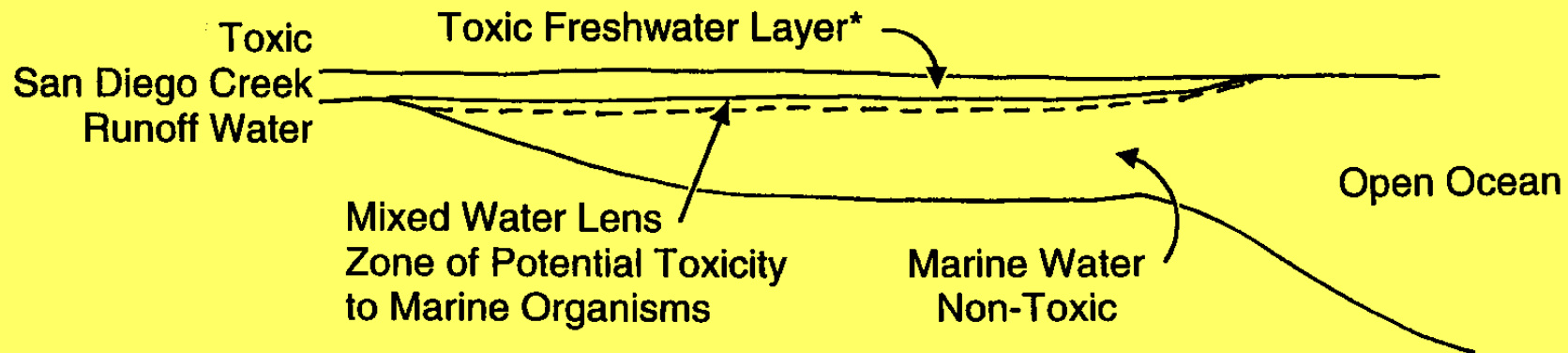
Upper Newport Bay OP Pesticide Toxicity

# Issues of Aquatic Life Toxicity Water Quality / Beneficial Use

- Is the Measured Toxicity Significantly Adverse to the Beneficial Uses of Waterbody?
  - What Types of Organisms Are Impacted?
    - For Lower Trophic-Level Organisms (Algae, Zooplankton), What Is Significance of Impact to Higher Trophic-Level Organisms of Importance to Public?
  - How Do the Beneficial Uses of Waterbody Change or Improve if Toxicity Is Controlled?

# Figure 1

## Upper Newport Bay OP Pesticide Aquatic Life Toxicity Situation



### Toxic Freshwater Mixes with Non-Toxic Marine Water

\* Under "Steady State" Conditions with Minimum Flow of 1500 cfs. At Lower Flow Rates, Bay May Be Only Partially Stratified, or, in Upper Bay, Fully Mixed, with Unknown Toxicity.



# Aquatic Sediments & Water Quality

- Aquatic Sediments Are “Sinks” (Reservoirs) for Chemical Constituents (Potential Pollutants)
  - Often Have Greatly Elevated Concentrations
- No Relationship between Total Concentration of a Constituent in a Sediment and Water Quality Impact
  - Variety of Mechanisms by Which Sediments Detoxify Many Chemical Constituents
  - Water Quality Impact Depends on Extent of Detoxification of Potential Pollutants
    - Depends on Several Non-Pollution Characteristics

(continues)

# Aquatic Sediments & Water Quality

- Chemical Concentration - “Co-Occurrence”-Based Sediment “Quality” Guidelines
  - Pairing of Concentration and “Impact”
  - Not Technically Valid for Identifying, Assessing, Estimating, or Predicting Potential Toxicity or Water Quality Impact
  - Based on Total Concentrations of Potential Pollutants
  - Ignores Aquatic Chemistry
  - No Cause-and-Effect Relationship
  - Coin-Toss More Reliable for Predicting Sediment Toxicity

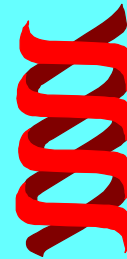
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# Aquatic Sediments & Water Quality

- Co-Occurrence-Based Sediment Quality Guidelines Not Reliable for Any Evaluation or Management Purpose
- Rather Than Try to Estimate/Predict Sediment Toxicity Based on “Co-Occurrence” Couplings, Measure Toxicity Directly
- “Toxicity” in Sediment Tests Is Not Equivalent to Significantly Impaired Fisheries

# Biomarkers

## Biochemical Responses



- Less-Than-Whole-Organism Response to Presence of Chemical
  - Shows There Has Been Exposure to Chemical
- Interesting Curiosity
  - Not Appropriate for Regulatory Tool at This Time
- Most Evaluate Relationships between Biomarker Response & Whole Organisms & “Community Impacts”

## **Conclusions**

- Current, So-Called “Water Quality Monitoring” Programs Typically Fall Far-Short of Providing the Information Needed to Develop Technically Valid, Cost-Effective Water Quality Management Programs
- Must Shift Emphasis of from Chemical Concentrations/Loads to Impacts of Chemicals on Beneficial Uses of Concern to the Public
- Recommend Evaluation Monitoring Approach

## Further Information

<http://members.AOL.com/gfredlee/gfl.htm>

