

Source Water and Drinking Water Early Warning System Research

水道水源の早期警戒システムに関する研究

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## Source Water and Drinking Water Early Warning System Research

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## Research Purpose

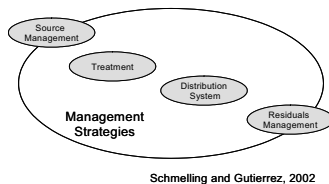
- Provide a systematic approach for the monitoring, provision and maintenance of water resources for the protection of aquatic habitat and human health
  - Source water protection
  - Finished drinking water in the distribution system



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## Research Model

### Drinking Water Contaminant Management Framework



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## Research Goals

- Evaluate various sensor technologies for their ability to detect changes in water quality in the source water and in a distribution system
- Develop guidance on development and implementation of Early Warning System (EWS) Networks



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## Research Approach

- Develop an understanding of available continuous, automated water quality monitors
  - Water Awareness Technology Evaluation Research Security Center (WATERS)
    - Physical/Chemical
  - Early Warning Systems Laboratory (EWSL)
    - Biological



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- EPA's Water Assessment Treatment Evaluation Research and Security (WATERS) Laboratory/Center



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## Evaluation Approach

- Off-the- Shelf Sensors/Monitors
  - finished water technologies
  - source water technologies
  - bio-sentinel technologies
- Innovative technology
  - advancing technology/sensors



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## Evaluation Approach (continued)

- Other media technology
  - agricultural & industrial
  - medical & pharmaceutical
  - chemical & manufacturing
  - academia to plumbing
- Technologies at the conceptual stage
  - research tasks can be completed concurrently



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**Distribution System Simulator**

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## Finished Water Monitors

- Chlorine – colorimetric & membrane electrode method
- Temperature – thermistor
- Dissolved Oxygen – membrane electrode method
- ORP – potentiometric
- pH – glass bulb electrode
- Turbidity – nephelometric (traditional & LED devices)
- Specific conductance - conductivity cell method

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## Finished/Treated Water Sensor - Monitors Multi-Parameter

- Dascore Six-Cense
  - potentiometric (sensors on a chip)
- Hach Aqua Trend Panel
  - GLI pH, temperature, sp. conductance
  - Cl-17 free chlorine
  - Hach 1720D turbidity

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## Source Water Monitoring Technologies (Multi-parameter Probes)

- Hydrolab DataSonde 4a
- YSI 6600
- Finished water parameters plus
  - Cl<sup>-</sup>, NO<sub>3</sub><sup>-</sup> & NH<sub>4</sub><sup>+</sup> - ion-selective electrodes

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## Process Monitors (Single-parameter)

- Hach Astro TOC
  - UV/persulfate method
- ATI A15 free chlorine
  - membrane electrode method

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## On-line Test Parameters

- pH, temperature
- ORP, specific conductance
- dissolved oxygen
- turbidity
- free chlorine
- TOC
- ammonia (NH<sub>4</sub><sup>+</sup>-N)
- nitrate (NO<sub>3</sub><sup>-</sup>-N)
- chloride (Cl<sup>-</sup>)

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## Project Objectives

- Qualitative
  - yes/no response for each contaminant and sensor
  - verify contaminant fate per known chemistry
- Quantitative
  - dose-response relationship
- Engineering
  - sensor placement / response time



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## Sensor Evaluation

- Sensor performance documented via
  - calibration intervals (drift)
  - service requirements (failures)
  - matrix interference & false positive response
  - comparison to grab sample results



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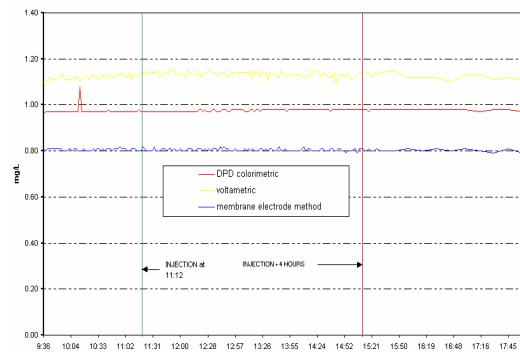
## Quality Assurance Quality Control

- Control Studies
  - loop water injection
  - no response noted on any sensors
- Cocktail Studies
  - chemical soup designed to cause a sharp response from each sensor
  - all sensors respond
- Dye Studies [75 seconds for Loop 6]



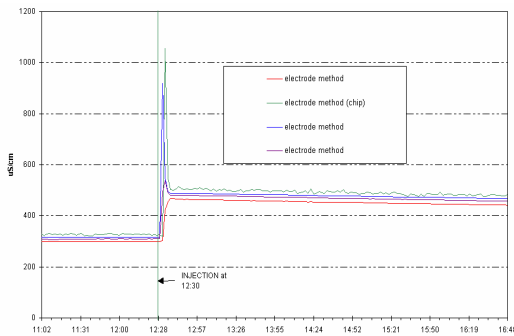
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## Control Studies - Free Chlorine



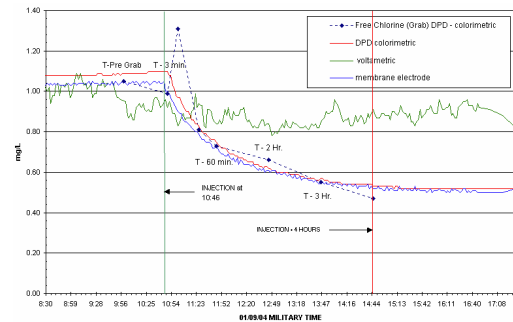
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## Cocktail Study - Sp. Conductance



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## Free Chlorine & Malathion



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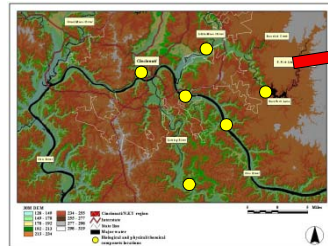
## Source Water Quality Bio-Sentinel Monitoring Systems

- Canary in the Coal mine
- Responses of biological material used to evaluate water quality
- No machine or analytical approach exists to measure toxicity
  - Only an organism in its own environment can integrate all factors that contribute to stress
  - Tier – 1 technology evaluation
  - Based on changes in water quality



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## WQMSs strategically deployed



-Data telemetered to central database for analysis



-Response triggers remote water sampler

-Watershed stakeholders notified of possible resource contamination

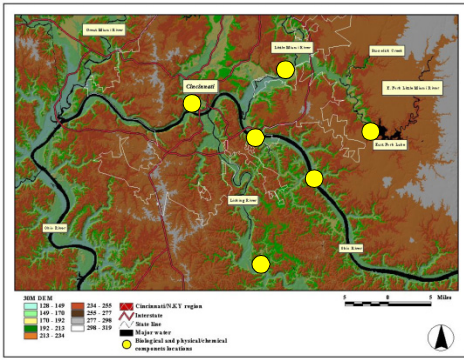
-Rapid verification of event to minimize uncertainty, identify/quantify contaminant for risk assessment or remedial/enforcement actions



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## Watershed EWS



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## Watershed Early Warning System Paradigm

1. Biological or physical/chemical parameter indicating changing conditions
  - Collect water sample
2. Verify water quality
  - Rapid toxicity assay (Daphnia IQ)
3. Determine toxicant using biologically directed chemistry (TIE)
4. Take appropriate action

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## Critical Properties of a WQMS

1. Measure record, and telemeter water quality parameters
  - toxicity, pH, D.O., Temp. ...
2. Ability to detect known contaminants
3. Ability to detect unknown contaminants
4. Time-relevant data analysis

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## Sensitivity Response Matrix

- Acute sensitivities derived from single toxicant assays.

	Fish	Bivalve	Cladocera	Algae
Copper	+	++	++	+
Cadmium	+	++	++	+
Diazinon	++	+	+++	-
Atrazine	-	-	-	+++
Toluene	+	+	++	+
Cyanide	++	++	++	-

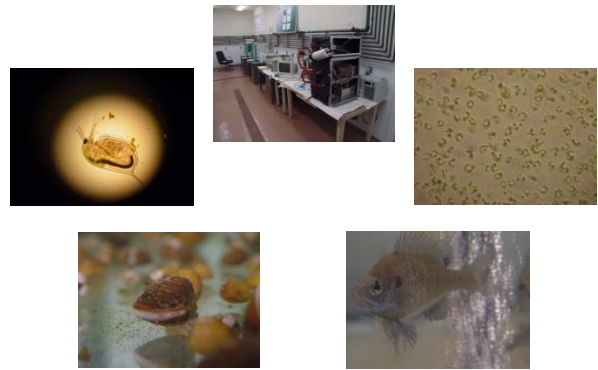
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## U.S. EPA Early Warning Systems Laboratory (EWSL)

- U.S. EPA Testing and Evaluation Facility, Cincinnati, OH
- Supports development, testing, and evaluation of
  - biologically based water quality monitoring systems
  - physical/chemical sensors



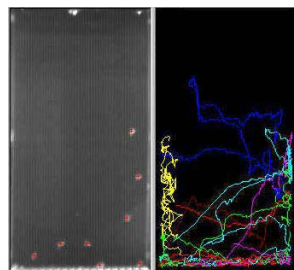
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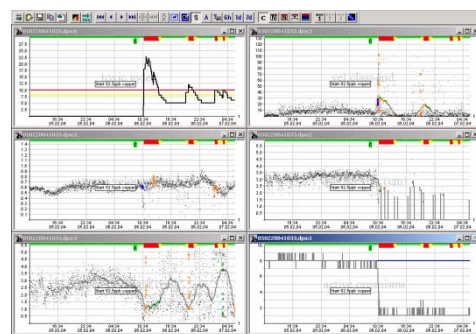
## Daphnia Behavior

- DaphTox by BBE Moldaenke
- Uses Digital Camera technology to track movement of 48-144 hour old *Daphnia Magna*



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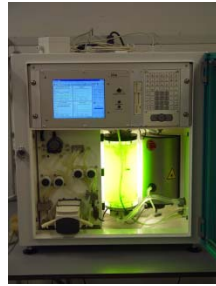
## 62.5 µg/L Copper



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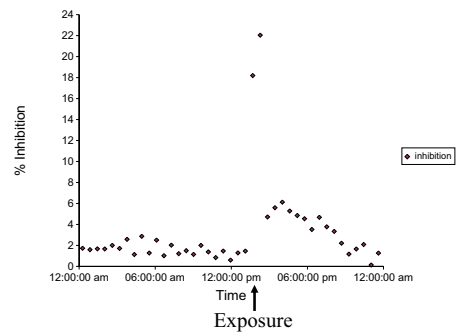
## Algae Fluorescence

- BBE Moldaenke Algae Online Analyzer
- Pulsed Amplitude Modulation fluorescence
- Measure of photosynthetic efficiency



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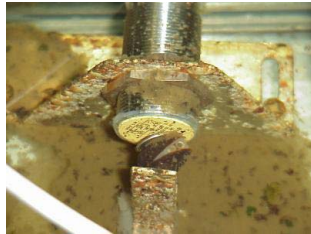
## 100µg/L Cyanide



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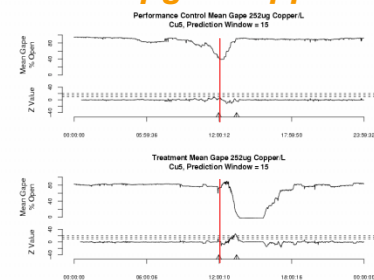
## Bivalve Gape

- Bivalves can isolate themselves from the environment
- Acute response
  - Shell closure
- Chronic response
  - Change in periodicity



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## 252µg/L Copper



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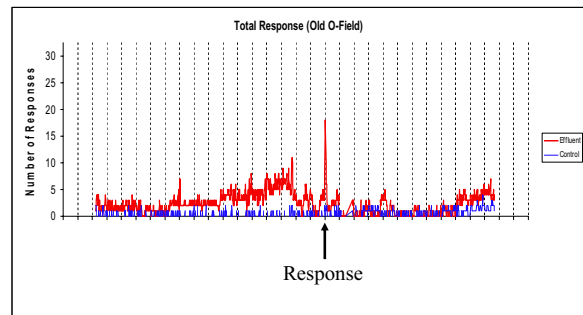
## Fish Ventilatory Response

- U.S. EPA – U.S. Army Center for Environmental Health Research Interagency Agreement
- Received September 2003



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## 500µg/L Copper



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## Sensitivity Response Matrix

- Acute sensitivities derived from single toxicant assays.

	Fish	Bivalve	Cladocera	Algae
Copper	500µg/L	176µg/L	<62.5µg/L	500µg/L
Cadmium	+	++	++	+
Diazinon	++	+	+++	-
Atrazine	-	-	-	+++
Toluene	+	+	++	+
Cyanide	1mg/L	++	100µg/L	100µg/L

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## EWS Partners

- Thomas More College
- Morehead State University
- Clermont County
- ORSANCO



Advanced Measurement Initiative Platform – AMI



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## Experimental Validation

- Correlate community and WQMS responses to sediment and toxicological challenges in stream mesocosms
- Work will be performed at the former P&G Experimental Stream Facility located on the EFLMR
- Duration of each experiment will be one year
- Develop basis for correlation of in-stream behavioral and community responses



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## Experimental Stream Facility



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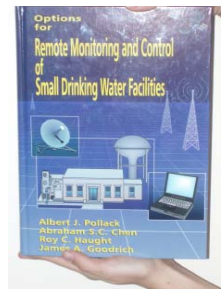
## Summary

- On-going standardized evaluation of WQMSs
- Development of multi-species WQMS
- Validation of WQMSs
- Implementation of Watershed Management/Early Warning System



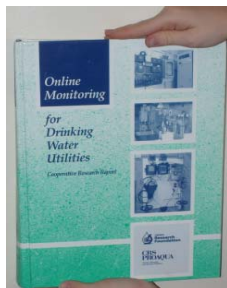
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## Remote Monitoring and Control of Small Drinking Water Facilities



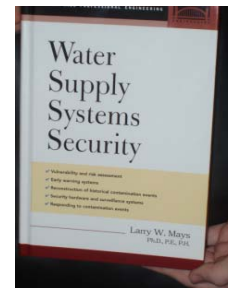
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## Online Monitoring



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## Water Supply System Security



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## Contact Information

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