# Biomonitoring Using Ecotoxicology

**Jerry L. Farris**
**Arkansas State University**
**Environmental Sciences Program**

# Aquatic Toxicology

- Presented at the
- AWEA Lab/Pretreatment Session
- AWW&WEA Conference

2003

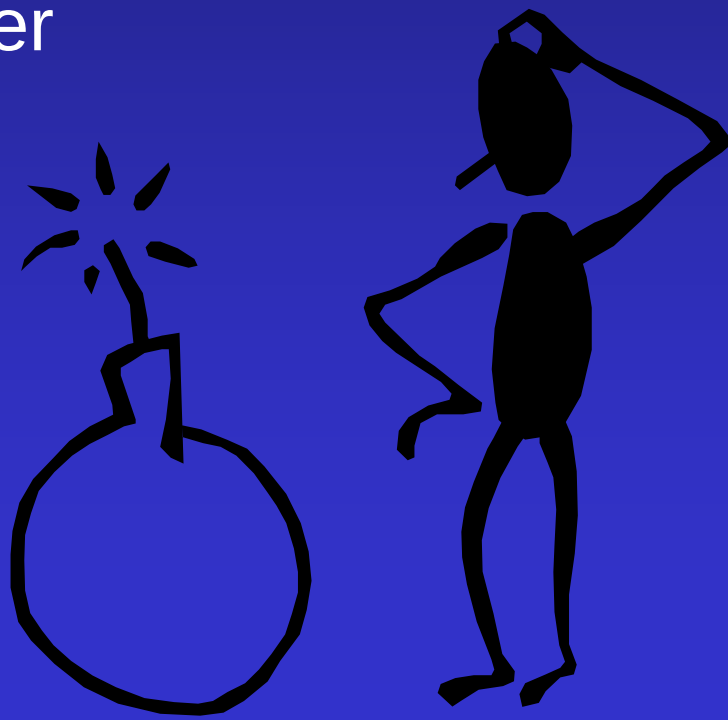
12th Annual AWEA Specialty Conference

Arkansas Water Environment Association

Water Environment Federation

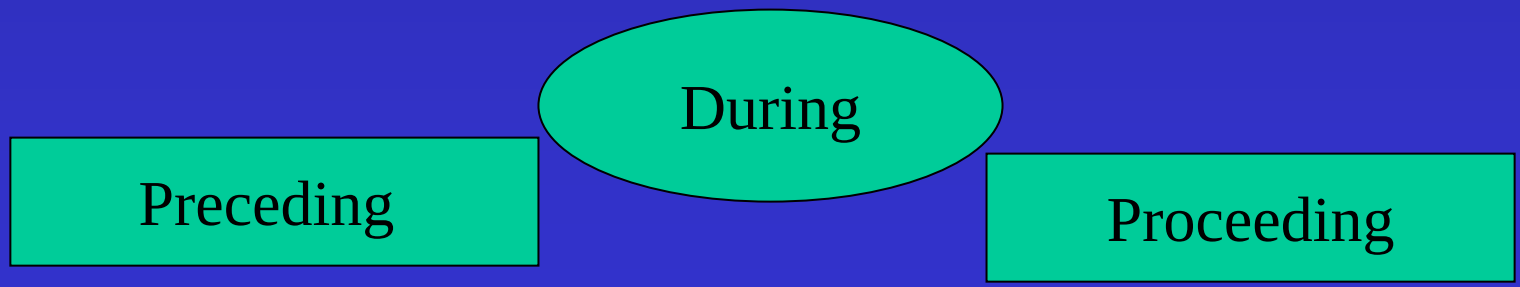
# PROBLEMS:

1. Type and degree of treatment
2. Flow from treatment plant
3. Characteristics of wastewater
4. Flow in receiving stream
5. Quality of receiving system
6. Amount/size of mixing zone
7. Uses of receiving waters



# Time and space relations

- Events
  - Spills, releases, catastrophe
- Predictions
  - Risk assimilation, transformation, etc.
  - Prominent or targeted use products
- Treatments
  - Recovery or condition



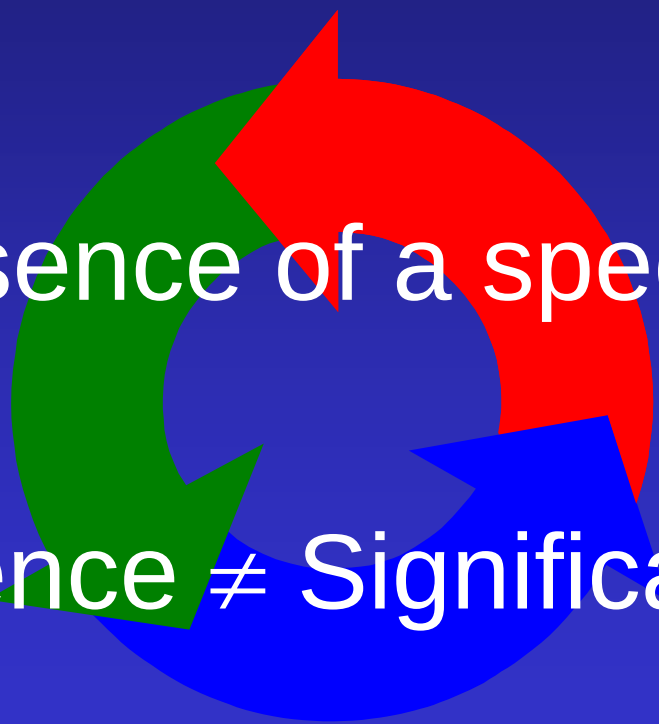
ASU
ARKANSAS STATE UNIVERSITY

EVS

# Arkansas State University Environmental Sciences Program

- providing scientific investigations to quantify sustainability

# Environmental Requirements



Presence of a species

Absence ≠ Significance

# Monitoring Changes

- Population numbers
- Community composition
- Ecosystem function

- genetic composition
- bioaccumulation of toxicants
- endocrine function
- biomarkers

# Human Health

Unmanaged ecosystem

**Loss of ecological services**

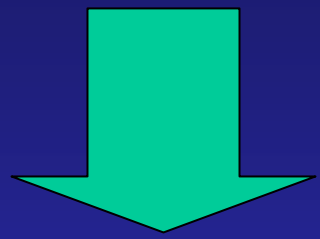
- **Drinking water**
- **Consumables**
- **Waste assimilation**

# Water Quality Standards
# Waste Discharge Requirements

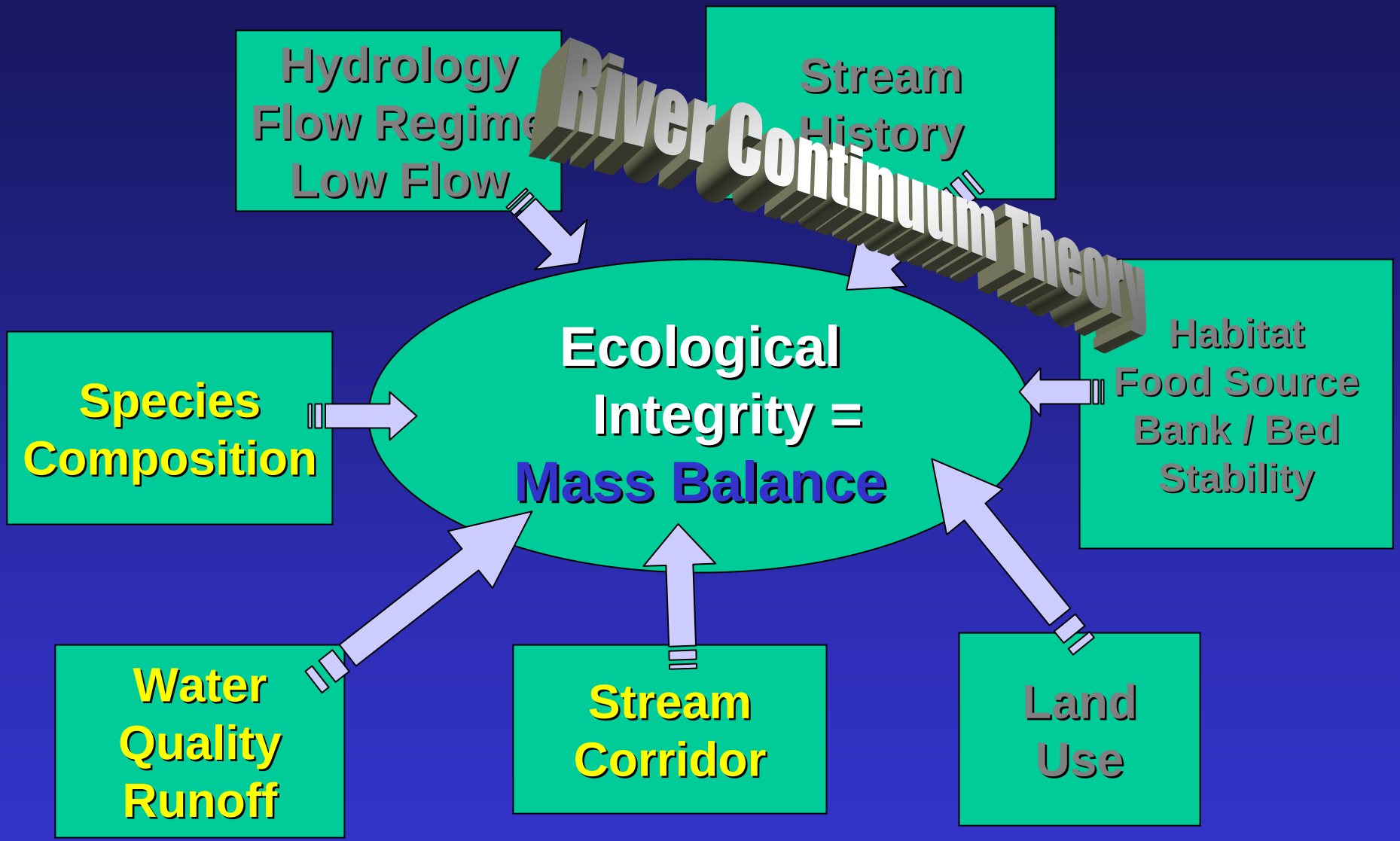
## Downstream Protection

- Domestic water supply
- Agriculture water supply
- Stock & wildlife water
- Propagation of aquatic life
- Swimming/boating
- Aesthetics
- Navigation
- Industrial use

# Environmental Health or Biological Integrity



- Biological monitoring
- Biomonitoring
- Toxicity testing - bioassays
- Water quality monitoring
- Environmental surveillance
- Compliance monitoring


Hydrology
Flow Regime
Low Flow
Stream
History
River Continuum Theory
Species
Composition
Ecological
Integrity =
Mass Balance
Habitat
Food Source
Bank / Bed
Stability
Water
Quality
Runoff
Stream
Corridor
Land
Use

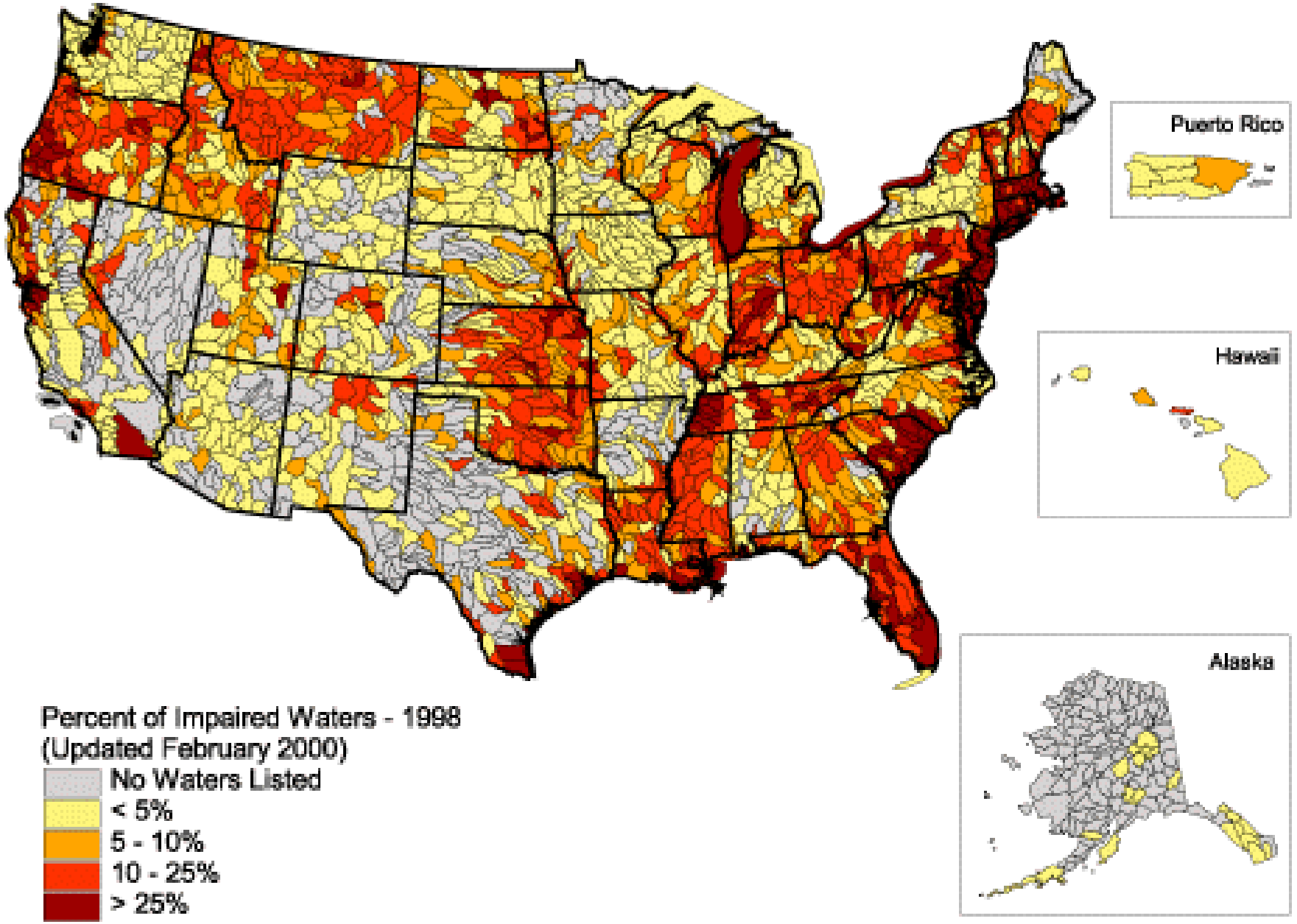
# TMDLs

- **Total**
- **Maximum**
- **Daily**
- **Loads (Loadings)**

# TMDLs

**TMDL = PS + NPS + MOS**

**PS = “POINT” SOURCE POLLUTION**
**NPS = “NON-POINT” SOURCE POLLUTION**
**MOS = MARGIN OF SAFETY**

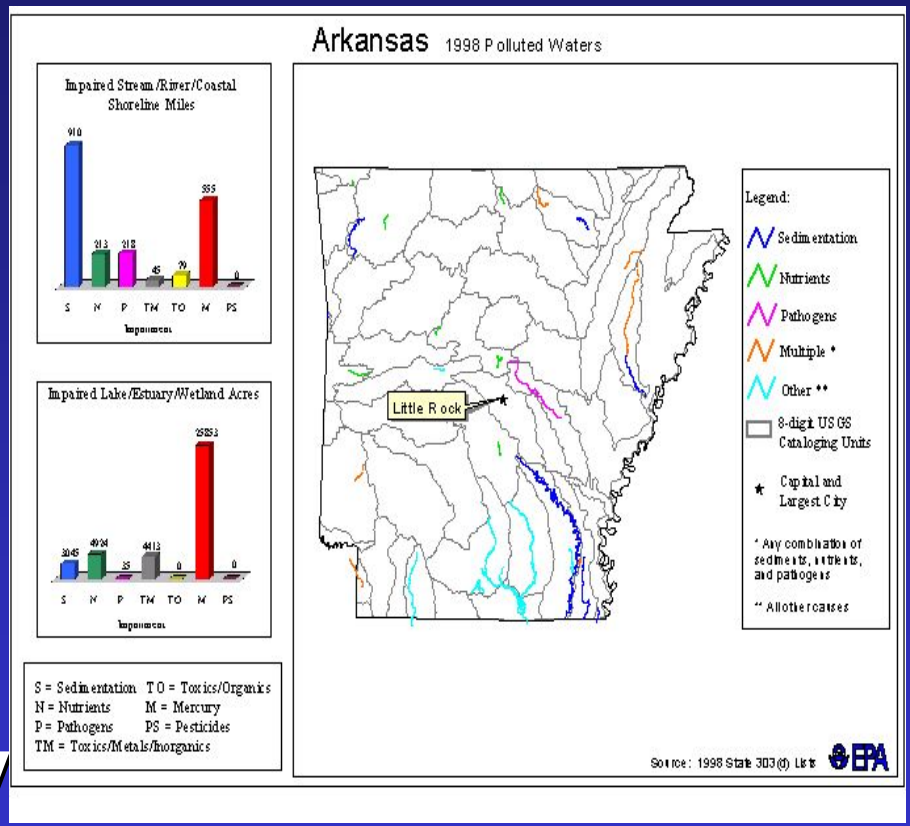

Puerto Rico
Hawaii
Alaska
Percent of Impaired Waters - 1998
(Updated February 2000)
No Waters Listed
< 5%
5 - 10%
10 - 25%
> 25%

# 303(d) List

- **What is it?**
  - Part of the CWA (1972) requiring states to identify waters not meeting state water quality standards
  - Developed every two years
- **What does it do?**
  - Essentially sets priorities for TMDL development
  - Develop a TMDL for each pollutant, for each listed water

# ARKANSAS

- ✓ 51 Waterbodies
- ✓ 70 TMDLs
- ✓ All monitored data
- ✓ 133 stations monthly
- ✓ 103 stations quarterly
- ✓ 30 parameters



# Arkansas vs. Mississippi

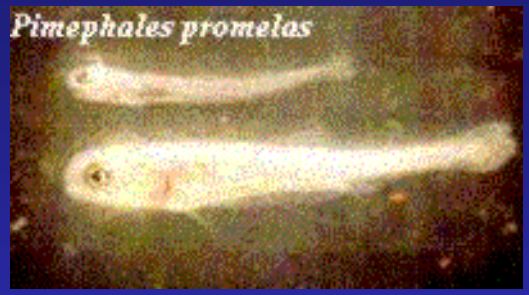
| | | |
|---|---|---|
| 21 | Siltation / Turbidity | 474 |
| 20 | Mercury | 16 |
| 10 | Nutrients | 468 |
| 6 | Pathogens | 228 |
| 6 | Chloride / Sulfide / TDS | 24 |
| 3 | “Heavy” metals | 12 |
| 2 | Ammonia | - |
| 1 | Priority organics | 7 |
| 1 | Organic Enrichment / low DO | 391 |
| - | Pesticides | 429 |
| - | Biological Impairment | 57 |
| - | pH | 52 |
| - | Suspended solids | 10 |
| - | Total toxics | 9 |
| - | Non-Priority organics | 7 |

# TMDL PROCESS--Arkansas

| IMPAIRMENT | |
|---|---|
| 34.5% | Agriculture |
| 34.5% | Unknown |
| 17.2% | Municipal |
| 6.9% | Industry |
| 3.4% | Road const/main |

# Maintenance of Biological Integrity

## ~consideration of surrogates and reference systems~


- **Community surveys**
- **In-stream monitoring**
- **Toxicity testing-bioassays**
- **Compliance Monitoring (WET)**

# TMDL PROCESS--Arkansas

**303 WATERBODIES (select from Eastern AR)**

**L'Anguille**
**(Siltation and Pathogens)**

**Bayou DeView**
**(Nutrients and Siltation)**

# Habitat Descriptors

Primary (1)

Riverine (5)

Evaluation codes related to ditch structure.

| Ditch Code | Size | Riparian Habitat | Water Regime |
|---|---|---|---|
| 1 | Primary | Bare | Dry |
| 2 | Secondary | Grass | Water, no flow |
| 3 | Tertiary | Brush/Shrub | Water, flow |
| 4 | Quartenary | Deciduous | Riverine |
| 5 | Riverine | --- | --- |

Secondary (2)

Tertiary (3)

Quarternary (4)

# Toxicity Evaluation

Aqueous toxicity  48-h acute

- *Ceriodaphnia dubia*
- *Pimephales promelas*

Sediment toxicity  10-day acute

- *Chironomus tentans*

# Benthic Macroinvertebrate Surveys

- US EPA Rapid Bioassessment Protocol
- Twenty jabs per 100-m reach

# MONITORING TRADE OFF

| Lab Bioassays | Field Bioassays | Field Monitoring |
|---|---|---|

High ← **Experimental Control** → Low

Low → **Environmental Realism** → High

# Quality, Control, Accountability

# Biomonitoring

| | |
|---|---|
| • Why organisms? | Concentrate & integrate from water particulates & sediments --- tissues |
| • Why transplants? | Experimental control & environmental realism |
| • Why bioaccumulation? | Integrated record of bioavailability |
| • Why growth? | Ecological measurement, dose-response population effects |
| • Why biomarkers? | Flags of exposure, archived samples |

# What can municipalities do?

- **Help lead recovery in systems listed for enforcement**
- **Participate in watershed groups giving stakeholders a chance to improve water quality before enforcement is necessary**

# TMDLs - Beyond the local watershed

**Gulf of Mexico Hypoxia Work group discussion on how to implement basin-wide program to alleviate “problems”**

**The “Win-Win” strategy:**

- ***Relies on states performing TMDLs**
- ***Using conservation practices & BMPs**
- ***Elevates TMDLs to new heights of popularity**

# RESEARCH APPLICATIONS

- Assimilative Capacity
- Complex Effluents - WET
- Additive Effects
- Instream Monitoring
- Site Variances
- Life Stage Assessment
- Propagation, Refuge, Recovery

# Ongoing related projects

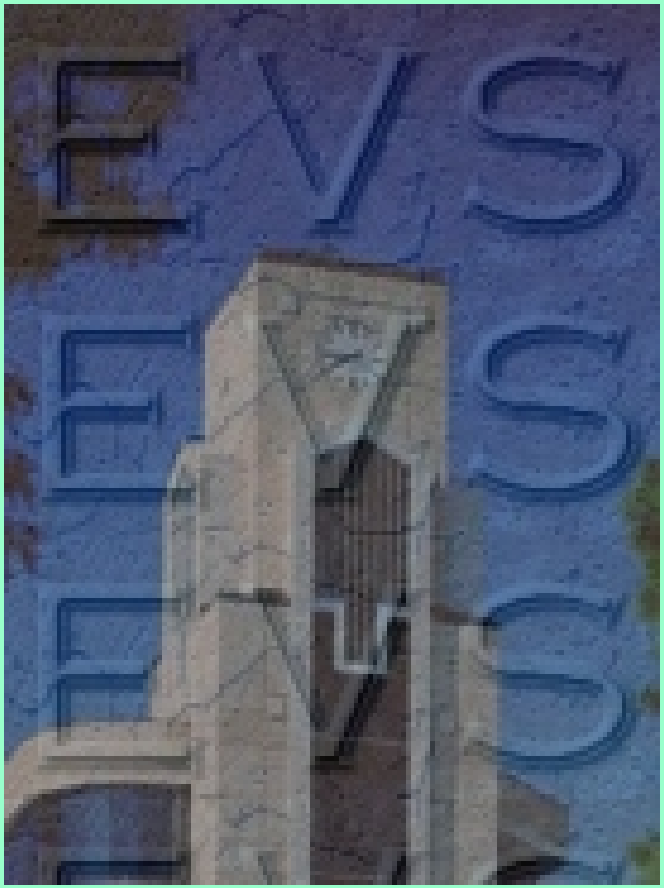
**Demonstration Erosion Control Project** **USDA/ Corps**

**Receiving Stream/ Reference Condition/ Evaluation** **Municipalities**

**Validation of Improved Conditions/ Industry-specific** **Aquaculture**

**Recovery Studies/ Long-term database development** **USDA/Industry**

**Estimate of Ecosystem services/ Ditches** **Agriculture/EPA / NSF**



# PhD in Environmental Science

- Environmental Chemistry
  - Water-Rock Interactions
  - Drinking Water Quality
  - Environmental Method Dev.
  - Climate Change
  - Chemical Toxicology
- Environmental Policy
  - Urban Planning
  - Environmental Economics
  - Agri-Economics
  - Environmental Justice
- Environmental Biology
  - Ecotoxicology
  - Ecology
  - Fisheries Management
  - Wildlife Management

# Acknowledgments

**ASU Ecotoxicology Research Facility**

**ASU EVS and College of Sciences and Mathematics**

**USDA National Sedimentation Laboratory**

**Judd Hill Foundation**

**CLW, CWL, and other municipalities and regional industries**

# Research support

- American Electric Power Service Corporation, Columbus, OH
- Hoechst Celanese, Rock Hill, SC
- Virginia Fibers Corporation, Amherst, VA
- EVS Environment Consultants, Seattle, WA
- R&R Environmental Engineering, Toledo, OH
- Tennessee Department of Transportation
- HydroQual, Inc., Mahwah, NJ
- U.S. Army Corps of Engineers, Memphis District
- Jones, Day, Reavis and Pogue, Toledo, OH
- Parsons Engineering Science, Inc., St. Louis, MO
- E2M Engineering-Environmental Management, Inc., Tulsa, OK
- CWL, Jonesboro, AR
- CLW, Paragould, AR
- OMI, Inc. for City of Fayetteville, AR
- City of Rogers, AR
- Fritt Industries, Walnut Ridge AR
- City of Trumann, AR
- City of Springdale, AR
- Weyerhauser, Hot Springs, AR
- Boston-Dana, Paragould, AR
- FTN, Inc. Little Rock, AR