



EPA/600/R-08/073  
May 2008



# Summary Report of the NSF/EPA WATERS Network Workshop

*April 30 - May 1, 2008*

## FOREWORD

The United States Environmental Protection Agency (EPA) is charged by Congress with protecting the nation's land, air, and water resources. Under a mandate of national environmental laws, the Agency strives to formulate and implement actions leading to a compatible balance between human activities and the ability of natural systems to support and nurture life. To meet this mandate, EPA's research program is providing data and technical support for solving environmental problems today and building a science knowledge base necessary to manage our ecological resources wisely, understand how pollutants affect our health, and prevent or reduce environmental risks in the future.

The National Risk Management Research Laboratory (NRMRL) is the Agency's center for investigation of technological and management approaches for preventing and reducing risks from pollution that threaten human health and the environment. The focus of the Laboratory's research program is on methods and their cost-effectiveness for prevention and control of pollution to air, land, water, and subsurface resources; protection of water quality in public water systems; remediation of contaminated sites, sediments and groundwater; prevention and control of indoor air pollution; and restoration of ecosystems. NRMRL collaborates with both public and private sector partners to foster technologies that reduce the cost of compliance and anticipate emerging problems. NRMRL's research provides solutions to environmental problems by developing and promoting technologies that protect and improve the environment; advancing scientific and engineering information to support regulatory and policy decisions; and providing the technical support and information transfer to ensure implementation of environmental regulations and strategies at the national, state, and community levels.

This publication has been produced as part of the Laboratory's strategic long-term research plan. It is published and made available by EPA's Office of Research and Development to assist the user community and to link researchers with their clients.

Sally Gutierrez, Director  
National Risk Management Research Laboratory



## NOTICE

The U.S. Environmental Protection Agency, through its Office of Research and Development, collaborated in the research described here. It has been subjected to the Agency's review and has been approved for publication as an EPA document.



The WATERS Network  
Project Workshop



# **Summary Report of the NSF/EPA WATERS Network Workshop**

May 2008



## Executive Summary

The National Science Foundation (NSF) and The U.S. Environmental Protection Agency (EPA) organized a workshop to support The WATER and Environmental Research Systems (WATERS) Network project. The WATERS Network is a new joint initiative of the environmental engineering and hydrologic sciences research communities with the support of NSF. The goal of the WATERS Network is to understand and predict the processes that couple water with earth and human systems through networked sensors, assimilation of high-frequency data, and interdisciplinary experimentation. Through real-time monitoring and modeling, water quality and quantity could be assessed at all times and at all places on a regional level. The WATERS Network would be a continental-scale research facility, possibly incorporating 10 to 12 tightly networked sites across the country. Eleven WATERS Test Bed projects are currently in operation. The EPA National Risk Management Research Laboratory (NRMRL) has a number of laboratory and field facilities that could potentially be integrated into the WATERS Network project. EPA/NRMRL and NSF are exploring the possibility of a partnership to produce projects that may serve as new WATERS Network Test Beds.

The NSF/EPA WATERS Network Workshop was held April 30 through May 1, 2008 in Cincinnati, Ohio. Technical experts from across the country specializing in areas of water quality and quantity participated in the workshop. The objectives of the workshop were to make the EPA/NRMRL facilities and staff capabilities known to academic community participants of this workshop, and to receive feedback from workshop participants on the potential for academic community collaboration through the envisioned NSF/EPA partnership.

On the first day of the workshop, the participants received an overview of the WATERS Network project and potential partnership between EPA and NSF, and descriptions of four EPA/NRMRL facilities. The group then visited two of these facilities, The Test & Evaluation Facility in Cincinnati, Ohio, and the Experimental Stream Facility in Clermont County, Ohio. On the second day of the workshop, the participants divided themselves among five breakout session categories charged to discuss the following: (1) the value of the proposed partnership to academic research, (2) potential research areas, and (3) issues of concern that may arise relative to academic community participation. Each group then presented a summary of their discussions and results, and these results were discussed further with the entire group. The five groups explored the following topic areas as they related to the WATERS Network and EPA partnership:

- Field Studies, Ecosystem Restoration, and Enhancement of Eco Services
- Technical Evaluation Facility
- Streams and Watersheds
- Modeling and Synthesis
- Institutions and Decision Making

The following sections summarize the major points and outcomes presented by each breakout group as they relate to their three charges.

### *Value of Partnership*

All groups saw merit to the proposed WATERS Network and EPA collaboration, as there are important benefits to be gained, such as leveraging of resources, the unique expertise of each other's programs, and



the ability to test concepts in the real world. Specifically, the following key points were made regarding the partnership:

- Partnership will provide concrete steps in developing cross-agency collaborations to address national issues.
- The WATERS Network focuses on water quantity issues, while EPA focuses on water quality, making collaboration complementary.
- EPA is developing its social science information and modeling capability; therefore, the proposed program could be a good way to focus on integrated research.

#### *Potential Research Areas*

The groups presented specific ideas to include EPA facilities in the Phase 2 WATERS Network funding proposal. The following key ideas were discussed regarding projects:

- Integration of information must be achieved across a wide range of disciplines, including engineering, hydrology, geomorphology, biology, data collection and systems, human processes and behavior, climate change, and social forces that respond to the water environment.
- Both engineering and hydrological aspects related to water quality and quantity must be balanced.
- The WATERS Network needs to incorporate a stronger urban/engineered process orientation, while EPA needs stronger science and engineering support for its infrastructure program.
- Existing watershed models need to be refined significantly and an appropriate suite of models are needed to interact with hydrogeologic and ecologic models.
- Models are needed that predict how land use today will affect watersheds for future generations.
- Cyberinfrastructure tools developed at NSF can benefit both EPA and NSF researchers.
- Social science is an important component that contributes to the evaluation of water.

#### *Issues of Concern*

Some concerns were expressed regarding the partnership and how it may affect the academic community's involvement. The main issues are presented below:

- Based on changing EPA priorities, concern was expressed about EPA's long term commitment to funding the project, and the availability of sufficient funds to conduct the project.
- Efficient financial and administrative procedures need to be in place to facilitate accomplishing project goals and objectives. This includes ownership and intellectual property rights.
- Reports and publication review needs to be streamlined and a mechanism developed for writing proposals collaboratively.

A series of follow-up steps to solidify the WATERS Network partnership were considered upon completion of the workshop. The first is to prepare and distribute the Workshop Report to the participants. NSF and EPA will develop a Memorandum of Understanding and determine the details of the financial partnership. Finally, NSF and EPA will begin planning to draft a Solicitation and Management Plan.



# The WATERS Network Project Workshop

Hosted by The National Science Foundation and  
EPA's National Risk Management Research Laboratory

Get to know the unique NRMRL research facilities and staff capabilities used to develop methods and create technologies that protect and sustain our water resources. EPA and NSF representatives will speak on the proposed EPA/NSF partnership and give informative presentations on the:

**Test and Evaluation (T&E) Facility, Cincinnati, Ohio**

Technologies for water and hazardous waste

**Experimental Stream Facility (ESF), Clermont County, Ohio**

Stream ecosystems

**Urban Watershed Research Facility, Edison, New Jersey**

Urban watershed engineering and best management practices

**Robert S. Kerr Environmental Research Center, Ada, Oklahoma**

Riparian and wetland restoration



## The WATERS Network Project Workshop



April 30, 2008

Dear Invited Workshop Experts:

On behalf of the National Science Foundation and the U.S. EPA National Risk Management Research Laboratory, we want to enthusiastically welcome you to this joint NSF/EPA WATERS Network Project Workshop. It is our desire for this workshop to bring together an unrivaled group of academic and government experts to explore potential research topics; where NSF-funded researchers will partner with EPA staff, at EPA research facilities, for projects related to the objectives of the WATERS Network.

It is envisioned that, subsequent to this Workshop, NSF/EPA will issue an open call to the academic community for proposals to be submitted to the WATERS Network-related NSF programs for joint collaborative research proposals in the 2009/2010 time frame. Successful proposals will share EPA facilities, staff, and data with ongoing research efforts.

As our honored experts, we ask that you:

- Provide feedback on the value of the proposed NSF/EPA partnership to academic research and education
- Outline example hypothetical partnership projects
- Identify potential issues, relative to academic community participation that could arise from this partnership

It is with many thanks and excitement that we welcome you to this joint NSF/EPA WATERS Network Project Workshop. We look forward to a stimulating and rewarding exchange of information and ideas!

Sincerely,

Dr. Bruce Hamilton  
Program Director  
National Science Foundation

Sally C. Gutierrez  
Director  
National Risk Management Research Laboratory



# The WATERS Network Project Workshop

## Agenda Oasis Conference Center

### April 29, 2008

- 3:00 p.m. Arrive and check in at Hilton Garden Inn
- 4:00 p.m. Early conference registration at Hilton Garden Inn (Eva Tankersley)
- 6:00 p.m. Reception at Hilton Garden Inn (Sally Gutierrez, Bruce Hamilton)

### April 30, 2008

- 7:00 a.m. Breakfast
- 8:00 a.m. Open registration at Oasis Conference Center (Eva Tankersley, Diana Ruffini)
- 9:00 a.m. Welcome by EPA (Sally Gutierrez)  
Welcome by NSF (Bruce Hamilton)
- 9:30 a.m. Overview of WATERS Network Project (Barbara Minsker, Paul Bishop)
- 10:15 a.m. Break
- 10:30 a.m. Overview of EPA/NRMRL facility resources
  - Test and Evaluation (T&E) Facility, Cincinnati, OH**  
Technologies for water and hazardous waste (Roy Haught)
  - Green Infrastructure Facility, Edison, NJ**  
Urban watershed engineering and best management practices (Mike Borst)
  - Experimental Stream Facility (ESF), Clermont County, OH**  
Stream ecosystems (Christopher Nietch)
  - Robert S. Kerr Environmental Research Center, Ada, OK**  
Riparian and wetland restoration (Bob Puls)
- 12:00 p.m. Working lunch with food for attendees
- 1:00 p.m. Coach arrives; available for boarding (Eva Tankersley)
- 1:15 p.m. Coach departs for Experimental Stream Facility (Jim Goodrich)
- 1:45 p.m. Tour Experimental Stream Facility (Christopher Nietch)
- 3:45 p.m. Travel to Test and Evaluation Facility (Roy Haught)
- 4:30 p.m. Tour Test and Evaluation Facility (Roy Haught)
- 6:15 p.m. Travel to Montgomery Inn Boathouse via coach (Eva Tankersley)
- 6:30 p.m. Dinner at Montgomery Inn Boathouse
- 8:00 p.m. Return to Oasis Conference Center via coach (Eva Tankersley, Diana Ruffini)





# The WATERS Network Project Workshop

## Agenda Oasis Conference Center

May 1, 2008

7:00 a.m. Breakfast

8:30 a.m. Overview of proposed EPA/NSF partnership (Jim Goodrich, Bruce Hamilton)

9:00 a.m. Charge to the breakout groups (Subhas Sikdar)

9:15 a.m. Breakout group sessions

**Field Operations—Field-Based Studies on Ecosystem Restoration and Enhancement of Ecosystem Services** (Alan Vicory, Bob Puls)

**T&E Facility Systems and Processes for Water, Wastewater, and Storm Water** (Nick Clesceri, Chuck Haas)

**Streams and Watersheds** (Patrick Brezonik, Christopher Nietch)

**Synthesis and Modeling** (Barbara Minsker, Dave Tarboton)

**Institutions and Decision Making** (Daniel Woltering, John Braden)

12:00 p.m. Working lunch with food for attendees

1:30 p.m. to 3:00 p.m. Reports from breakout groups, wrap-up, and adjourn



The WATERS Network  
Project Workshop



# **NSF/EPA WATERS Network Workshop**

April 30 – May 1  
Cincinnati



# Workshop Background

- The WATERS Network (WN) is in the conceptual planning phase at NSF—officially designated “Horizon MREFC Project” stage
- WN would be a continental scale research facility, with perhaps 10-12 tightly networked sites across the country
- Ballpark capital cost of WN might be \$250-300 million
- Currently, WN has 11 “Test Beds” operating across the country, plus several “CI Prototype” and other sites
- WN PI Barbara Minsker (UIUC) will describe WN in more detail later this morning



## Workshop Background (cont'd)

- EPA/NRMRL has a number of laboratory and field facilities across the country that could potentially relate to the WN project
- These EPA/NRMRL facilities will be described later this morning, and two will be toured this afternoon



## Workshop Background (cont'd)

- EPA/NRMRL and NSF are exploring the possibility of a partnership related to WN
- In principle, NSF/EPA partnership projects might serve as new WN Test Beds
  - For WN, this would have the benefit of building on EPA's existing facilities and capabilities
  - For EPA, the benefit might be enhancement of already existing facilities and capabilities



# Workshop Objectives

- Make the EPA/NRMRL facilities and staff capabilities known to academic community participants of this workshop
- Receive feedback from workshop participants on the potential for academic community collaboration through the envisioned NSF/EPA partnership



## ***Potential guidelines for research projects funded through the NSF/EPA partnership***

- Research would be performed at EPA sites
- Research teams would be composed of university researchers and students teamed with EPA researchers at EPA sites
- University researchers and students would be supported by NSF grants (up to \$300K per grant)
- To request grant funding, university PIs would submit a proposal to NSF in response to a solicitation that might be posted by NSF (after concurrence by EPA), perhaps in 2009
- Each proposal from a university PI should include a letter from an EPA partner stating the intention to collaborate



# Workshop Agenda

- **Day 1 Morning**

- Welcome (by EPA, NSF)
- WN Overview (WN PI Barbara Minsker [UIUC] )
- Break
- Presentations on EPA/NRMRL facility resources

- **Lunch**

- **Tour of Two Local EPA Facilities**

- Experimental Stream Facility (ESF)
- Test and Evaluation Facility (T&E Facility)

- **Dinner**





# Workshop Agenda (cont'd)

## •Day 2 Morning

- Overview of proposed EPA/NSF partnership
- Charge to the breakout groups
- Breakout group sessions (five in parallel)

- Field operations—Field-Based Studies on Ecosystem Restoration and Enhancement of Ecosystem Services
- T&E Facility Systems and Processes for Water, Wastewater, and Storm Water
- Streams and Watersheds
- Synthesis and Modeling
- Institutions and Decision Making

## •Lunch

## •Reports from the breakout groups

## •Discussion and wrap-up



## Anticipated Breakout Group Outputs

- Feedback from the academic community on the value of the proposed NSF/EPA partnership to academic research and education
- Outlines of example hypothetical partnership projects
- From the viewpoint of the academic community, some indications of issues, if any, that might arise in the partnership, relative to academic community participation



The WATERS Network  
Project Workshop



# The WATERS Network

Barbara Minsker and the  
WATERS Network Design Team  
NSF/EPA WATERS Network Workshop  
April 30, 2008



*WATERS NETWORK*

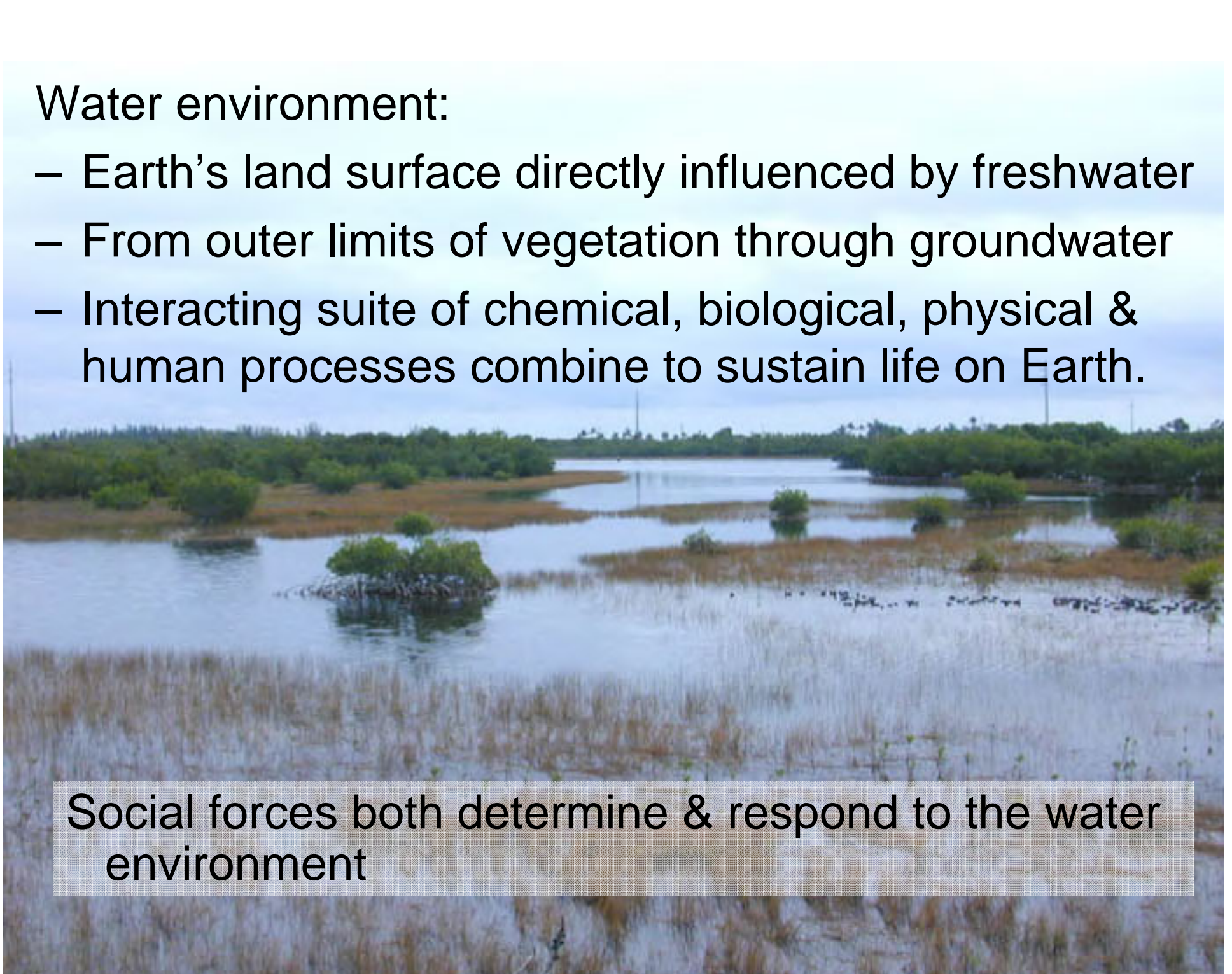
WATERS Network Goal: Understand & predict the multi-scale processes coupling water with Earth & human systems

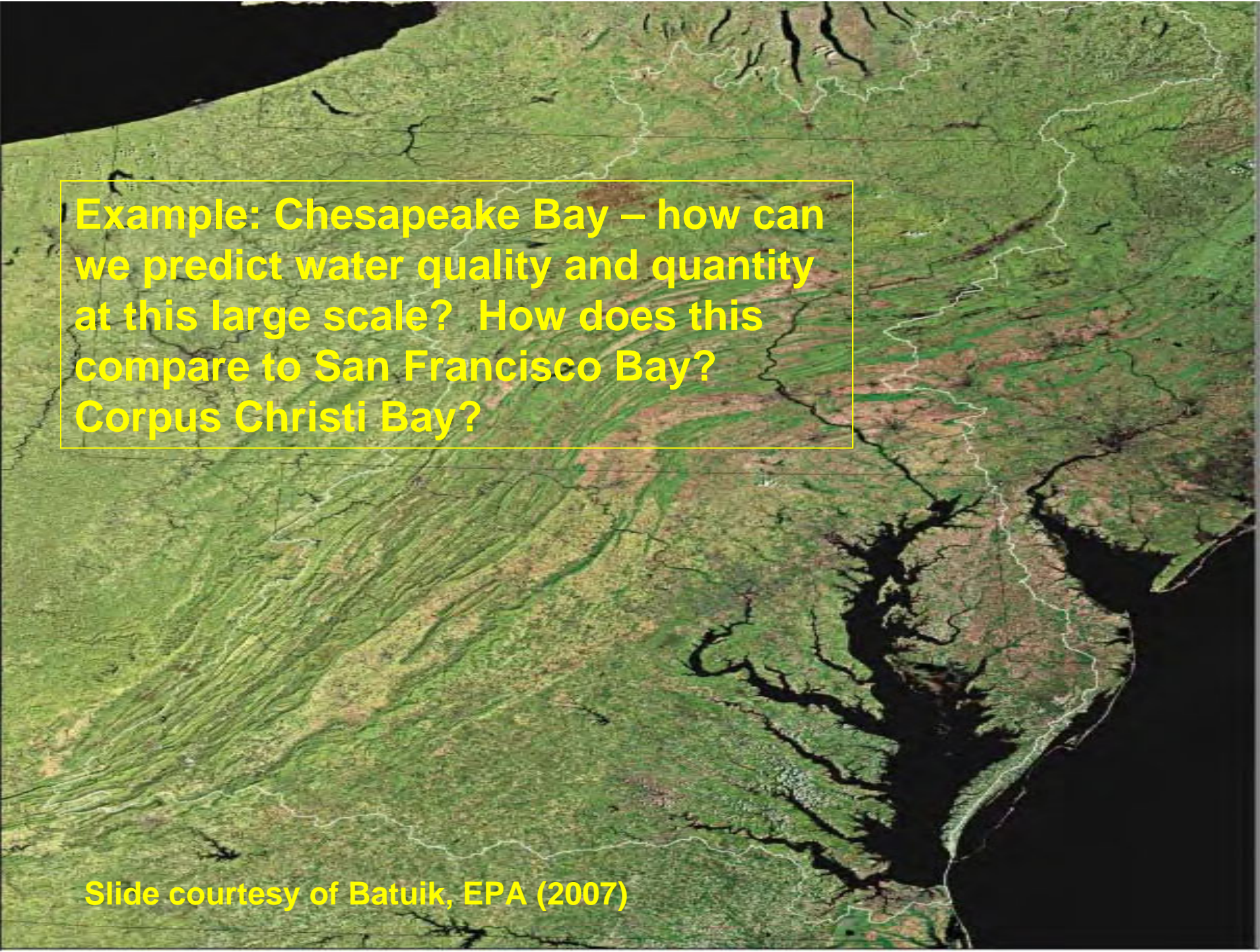


## Water environment:

- Earth's land surface directly influenced by freshwater
- From outer limits of vegetation through groundwater
- Interacting suite of chemical, biological, physical & human processes combine to sustain life on Earth.

Social forces both determine & respond to the water environment

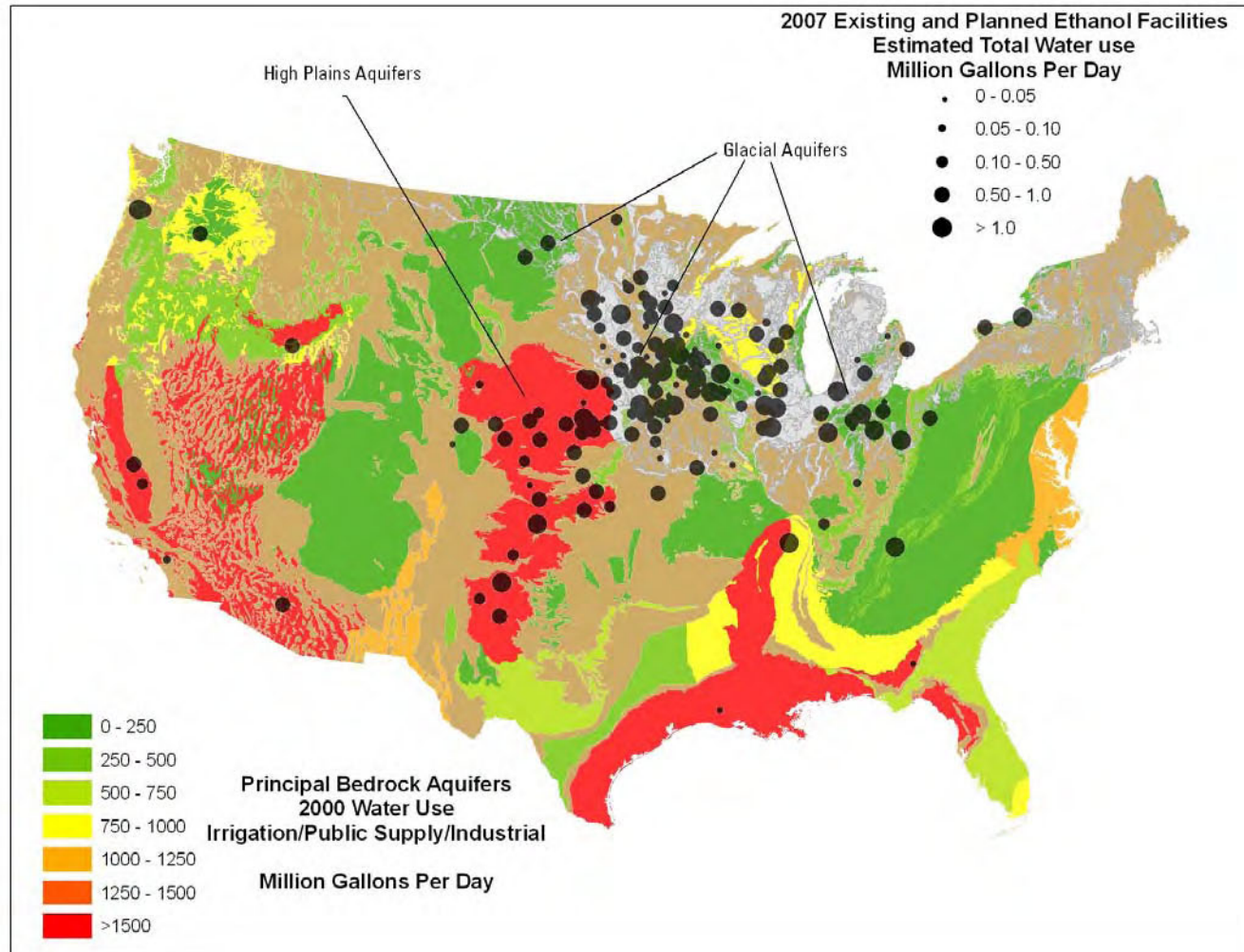




**Example: Chesapeake Bay – how can we predict water quality and quantity at this large scale? How does this compare to San Francisco Bay? Corpus Christi Bay?**

**Slide courtesy of Batuik, EPA (2007)**

# Another Example: Large-scale effect of Biofuels expansion in U.S.



## Gulf of Mexico hypoxia caused by runoff from Mississippi Basin

In 2007, dead zone was 7,900 mi<sup>2</sup> (21,000 km<sup>2</sup>)

What will be the impacts of targeted BMPs and/or changes in centralized and decentralized treatment?



Photo by N. Rabalais

Mississippi River meets the Gulf of Mexico  
(Source: <http://www.gulfhypoxia.net>)



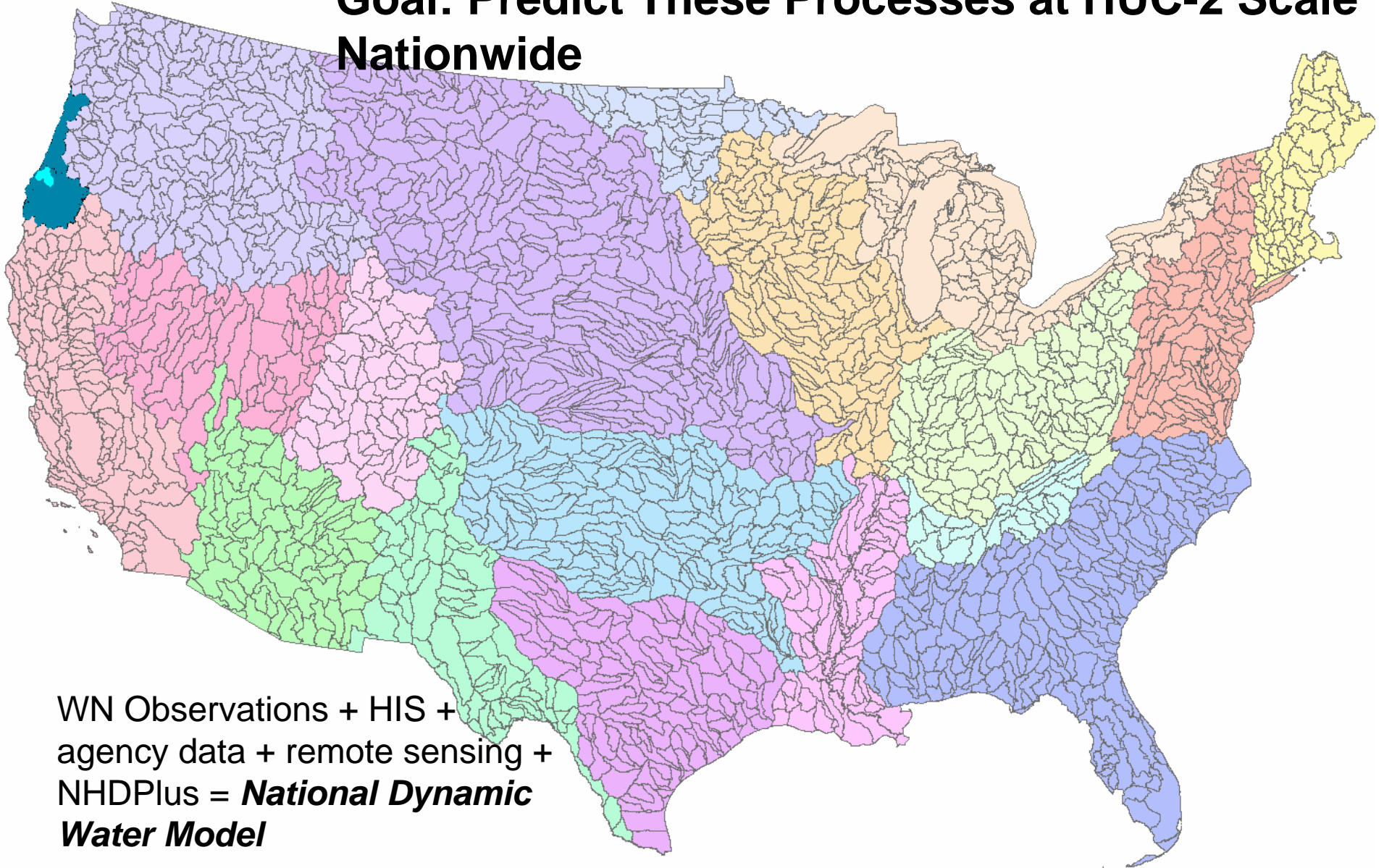
Living sustainably requires a predictive understanding of:

- Water & contaminant stores and fluxes
- Their inter-relationships with:

- Surface environment processes
- Human processes (behaviors, treatment technologies, policies, etc.)



# Goal: Predict These Processes at HUC-2 Scale Nationwide



WN Observations + HIS +  
agency data + remote sensing +  
NHDPlus = ***National Dynamic  
Water Model***

# Natural Systems

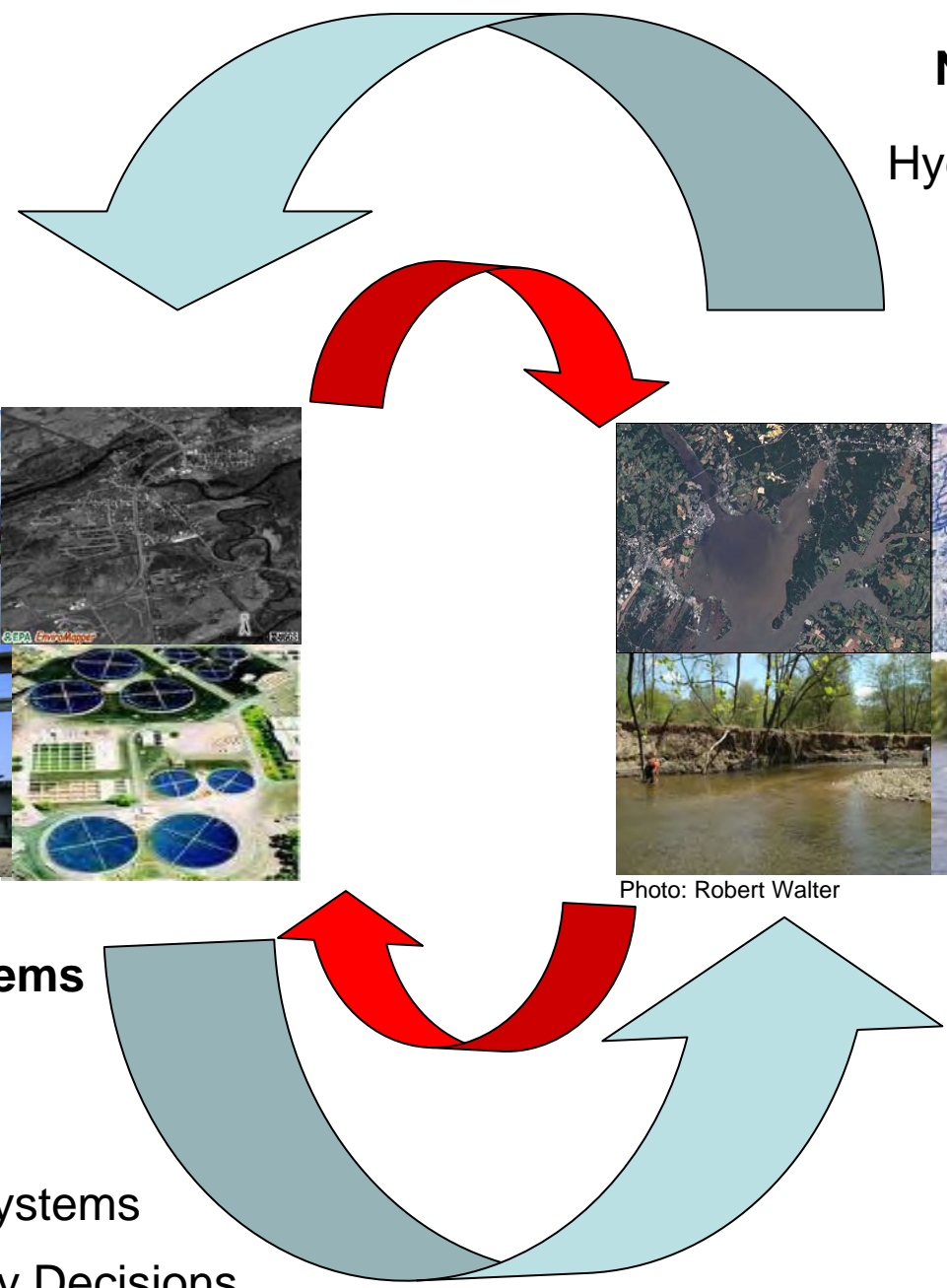
- Hydrology
- Geomorphology
- Biogeochemistry
- Ecology



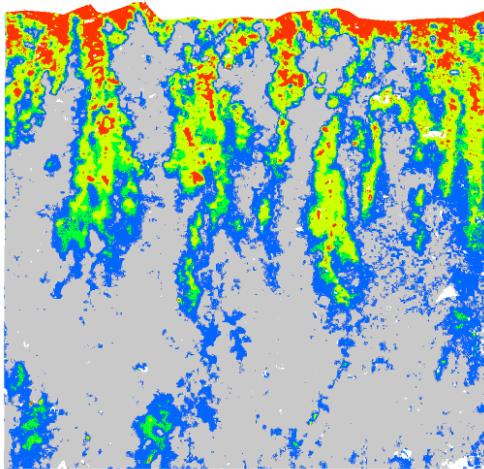
Photo: Robert Walter

# Human Systems

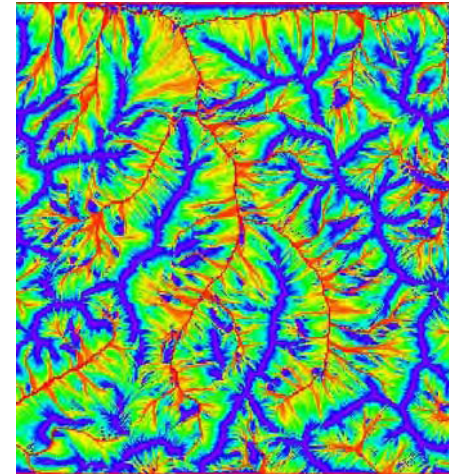
- Human Behavior
- Infrastructure
- Engineered Systems
- Policy Decisions



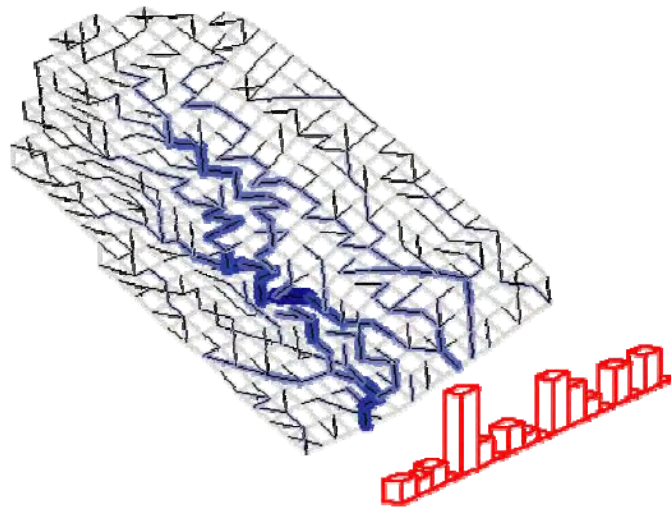
# Scaling in the Natural Water Environment



Small-scale preferential infiltration, Weiler

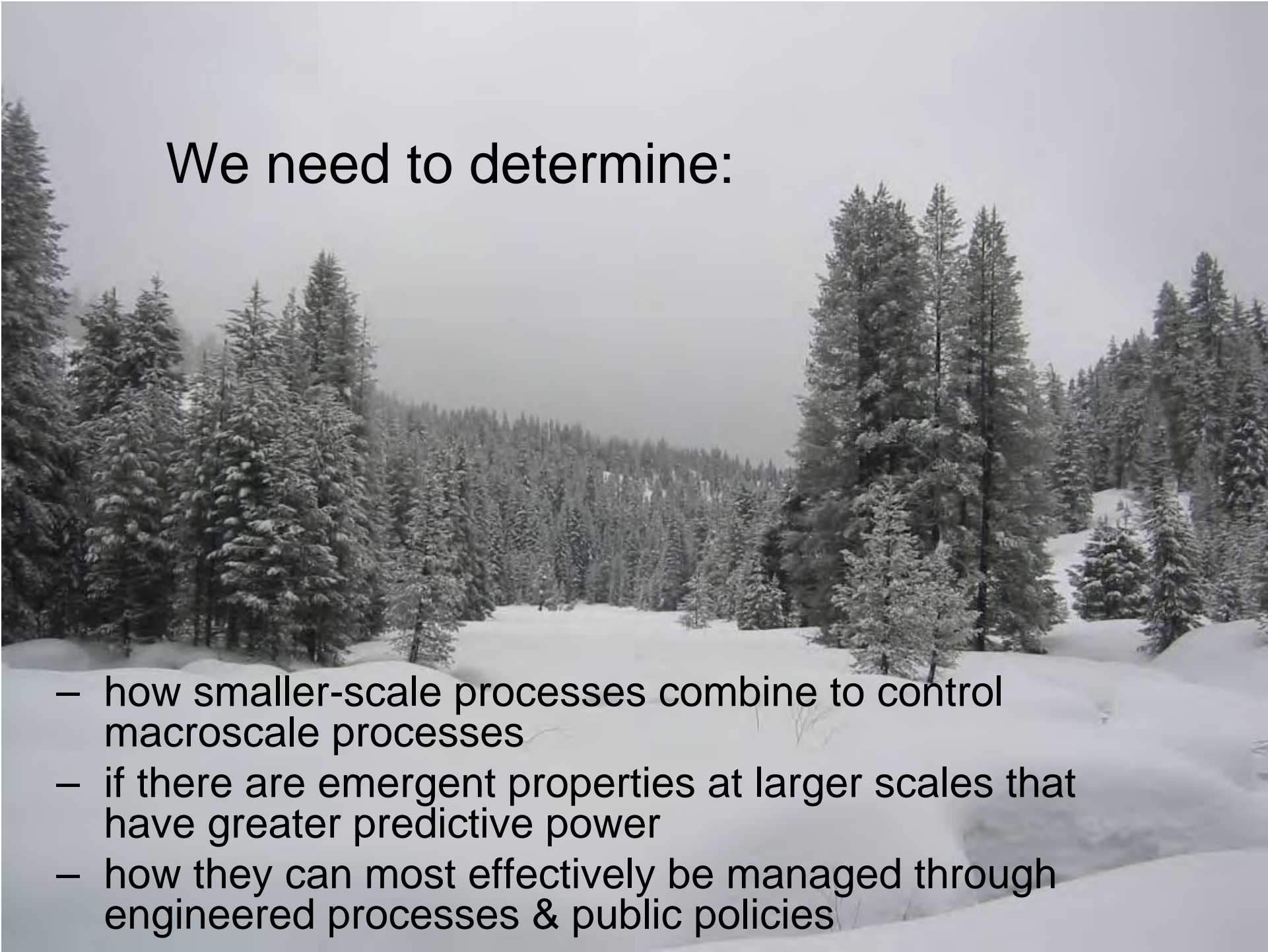


Watershed-scale contributing area network



Hillslope-scale preferential flow-path network, Weiler, McDonnell

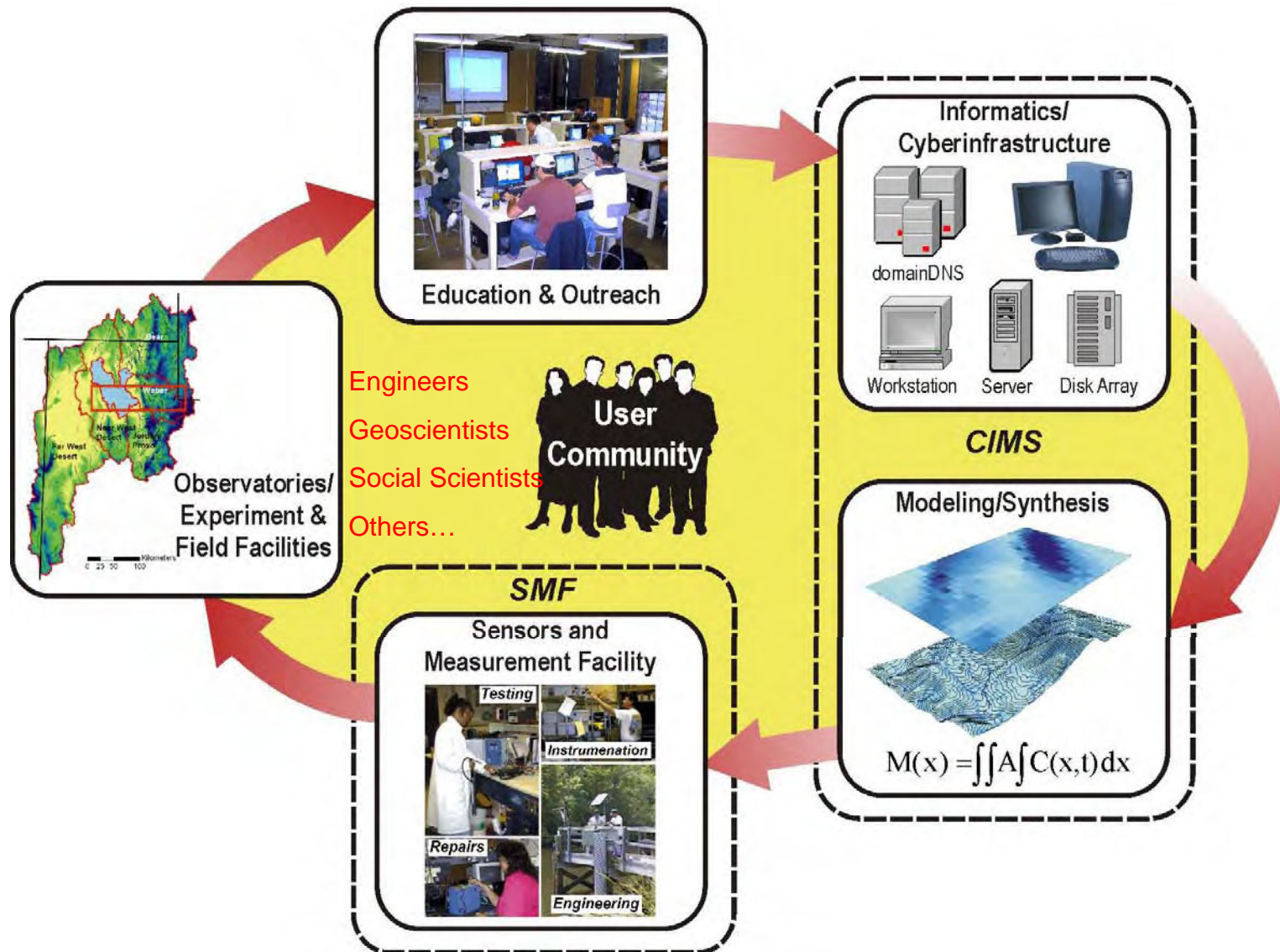




We need to determine:

- how smaller-scale processes combine to control macroscale processes
- if there are emergent properties at larger scales that have greater predictive power
- how they can most effectively be managed through engineered processes & public policies

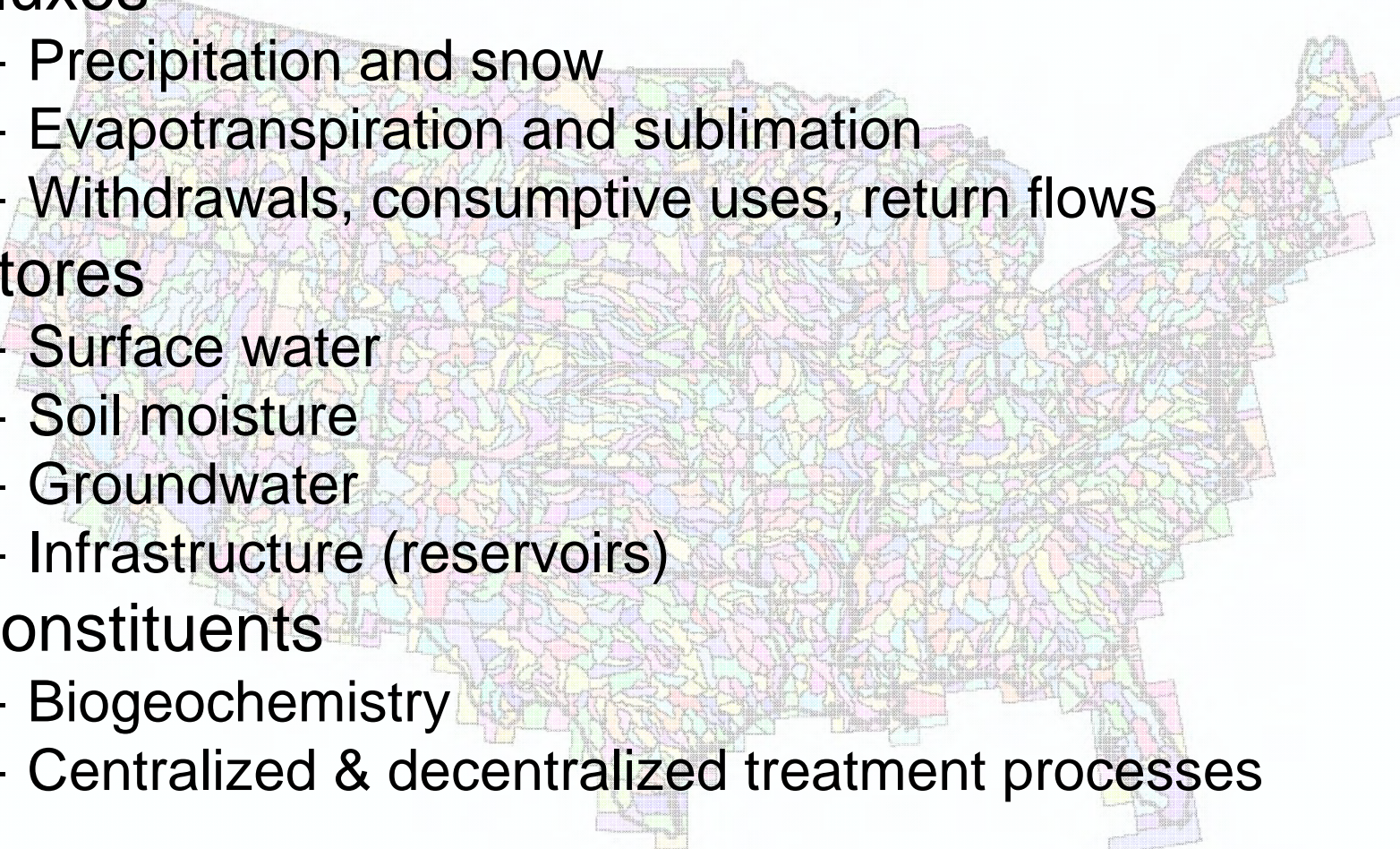
# WATERS Network: Advancing Multi-Disciplinary Knowledge Through Integrated Infrastructure



WATERS Network would address heterogeneity with coincident, high-frequency, spatially distributed data from representative sites across the continent



# Integrated data product needs

- Fluxes
    - Precipitation and snow
    - Evapotranspiration and sublimation
    - Withdrawals, consumptive uses, return flows
  - Stores
    - Surface water
    - Soil moisture
    - Groundwater
    - Infrastructure (reservoirs)
  - Constituents
    - Biogeochemistry
    - Centralized & decentralized treatment processes
- 



# Human Influenced Water Resource Classification (HIWRC)

- Capture the diverse hydrologic conditions that exist across the US.
- Set of variables that quantify hydrologic setting, both physical and human influenced
- Variables mapped to ordinal scale
- Principal Component and ISODATA Cluster Analysis



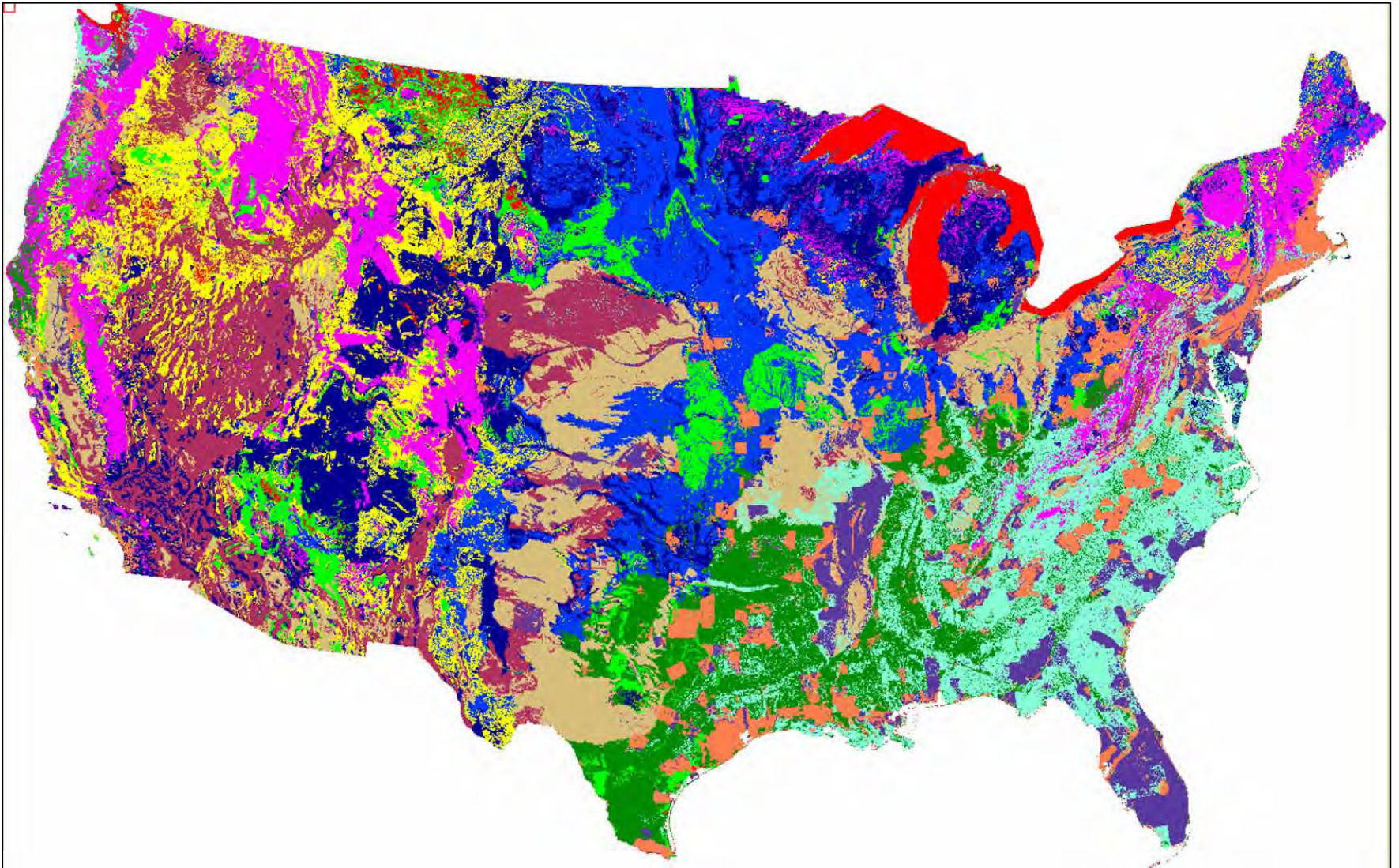
Hutchinson and Schnoor – Appendix B, SEDS document

# HIWRC Variables

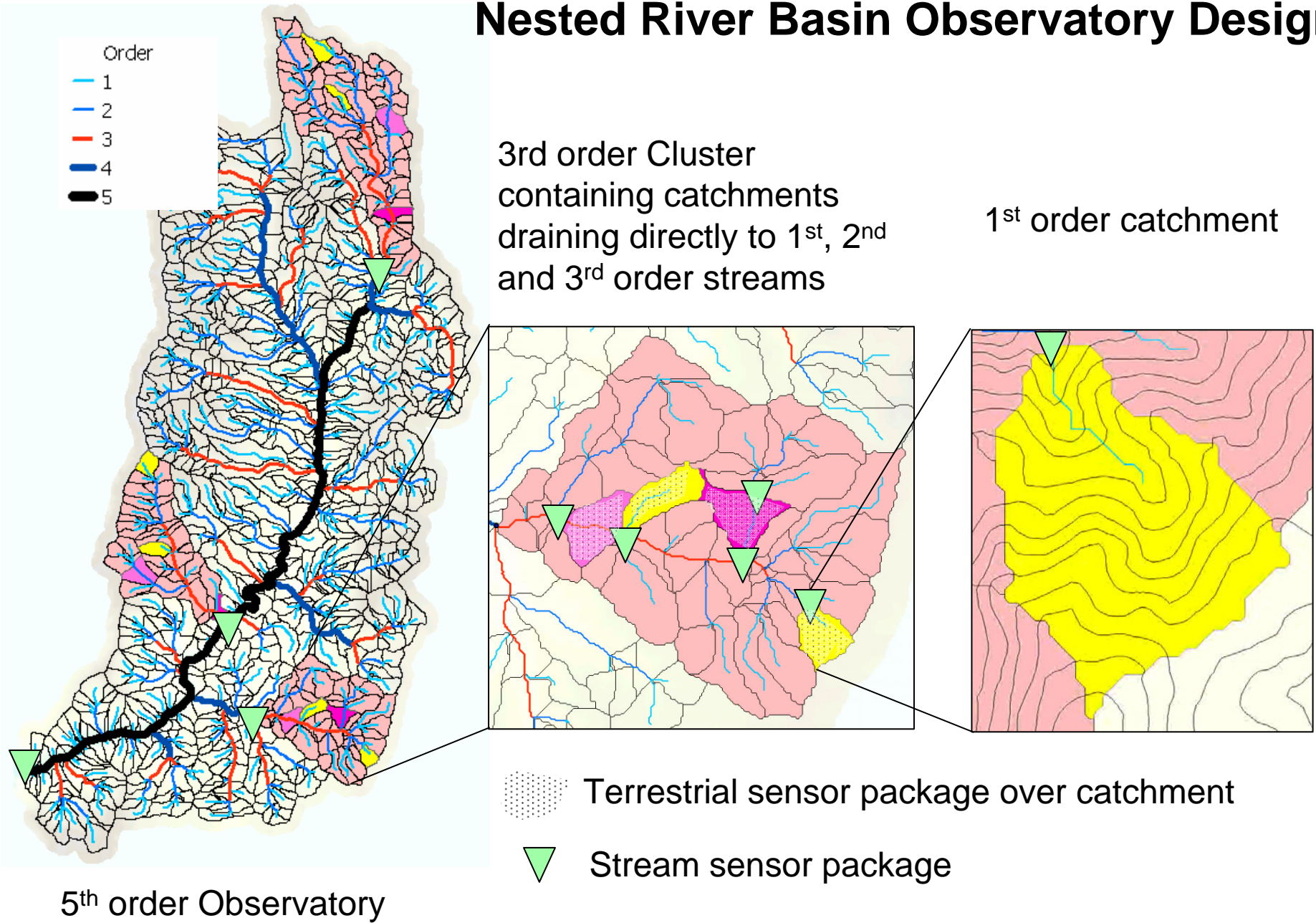
- Population Density (2000 Census)
- Land Cover (NLCD, 2001)
- Precipitation (PRISM)
- Temperature (PRISM)
- Soil Permeability (from STATSGO)
- Slope (as derived from NED by PRISM)
- Bedrock Permeability (from USGS lithologic group)
- Water Use (USGS 2000 National  
Aggregate Water-Use Data System)



# Twelve Delineated HIWRCs

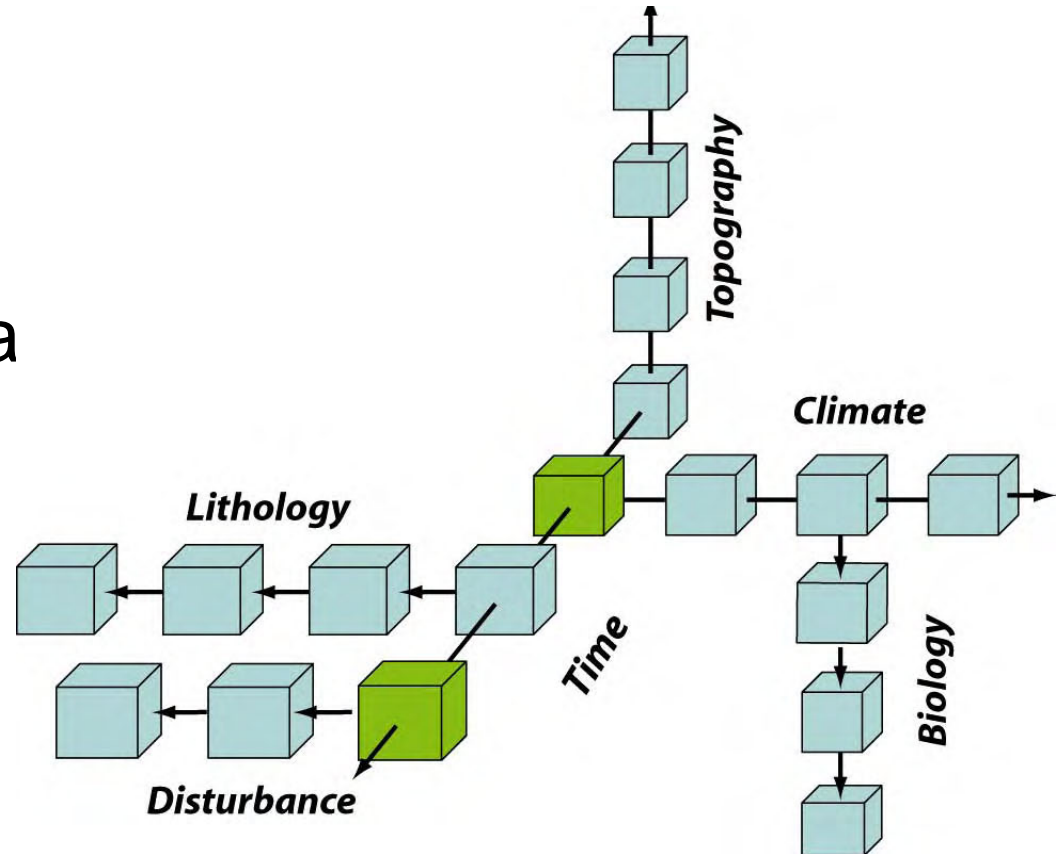


# Nested River Basin Observatory Design

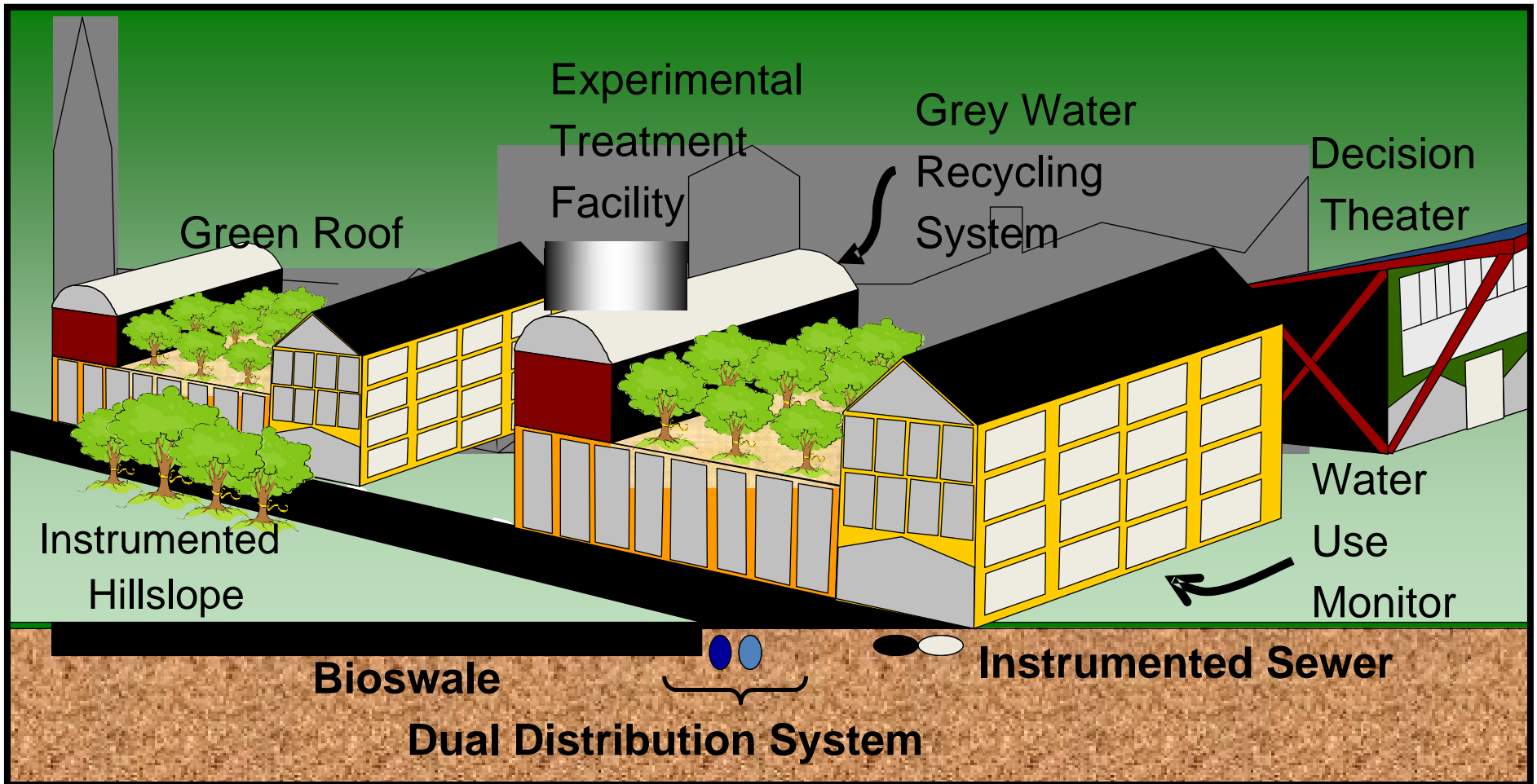


# Gradient Observatory Design

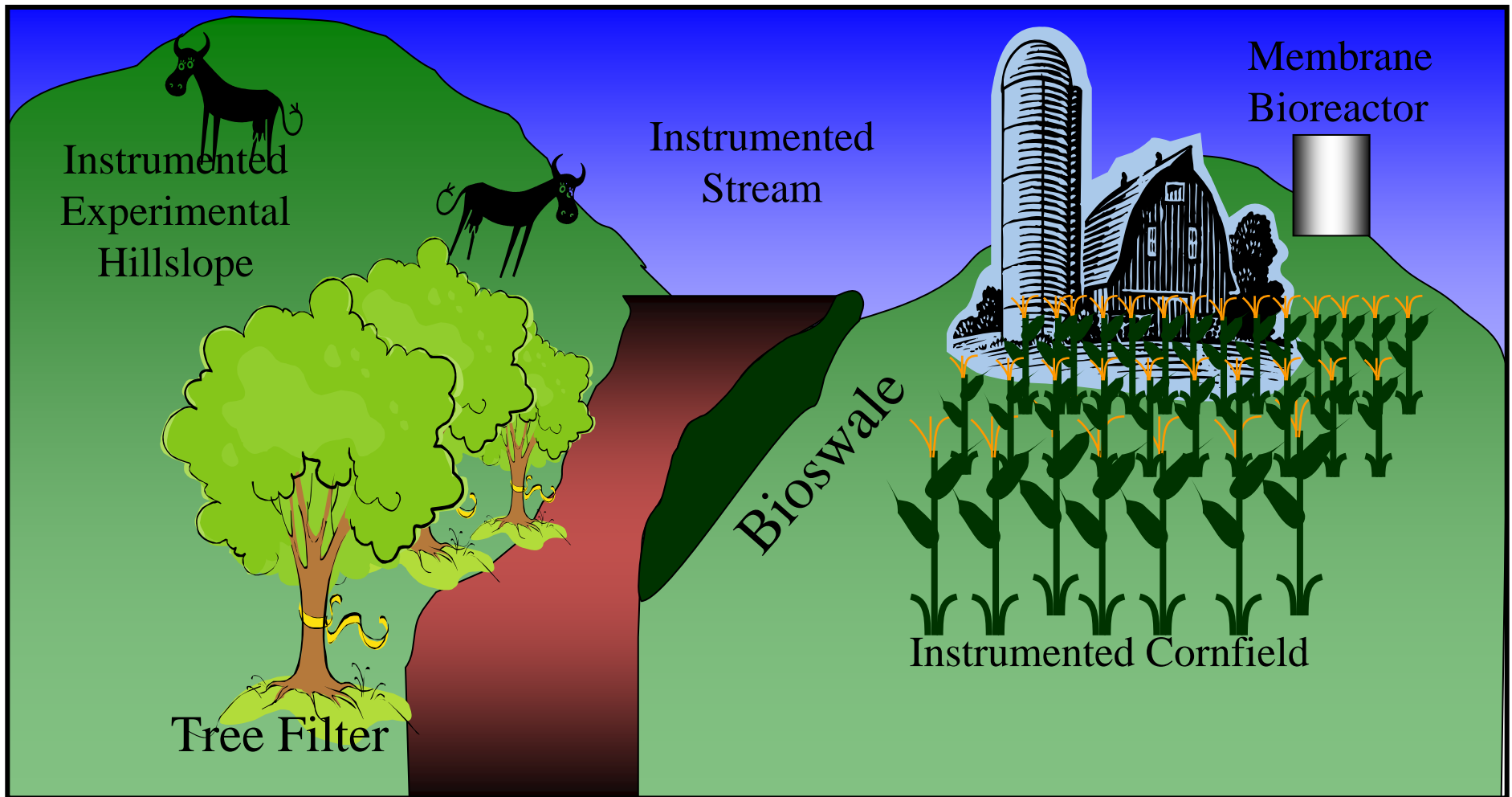
Systematic data collection across gradients to allow isolation of individual causative factors



# Experimental Village

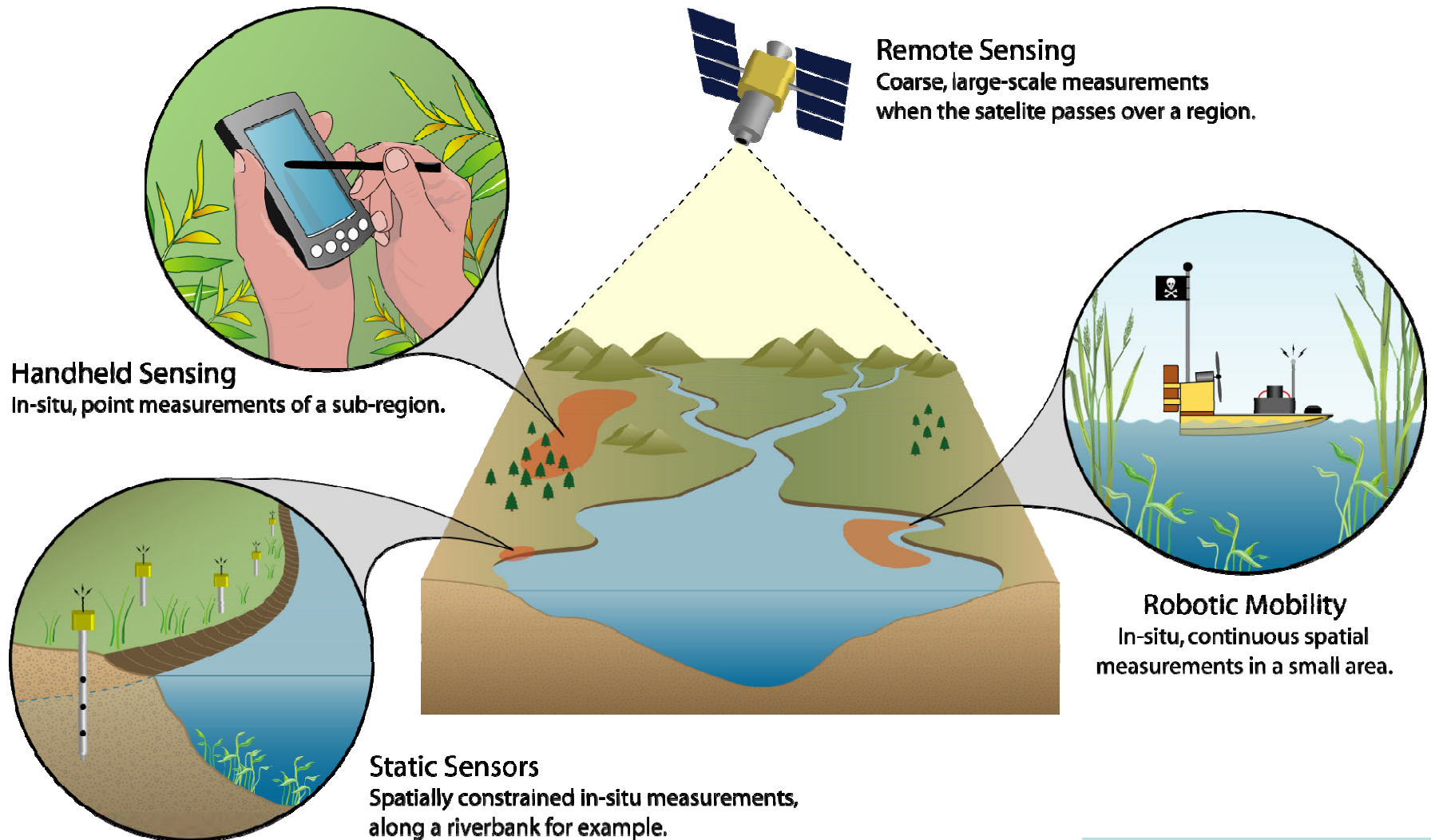


# Experimental Farm



# Multi-scale and Multi-Modal Sensing

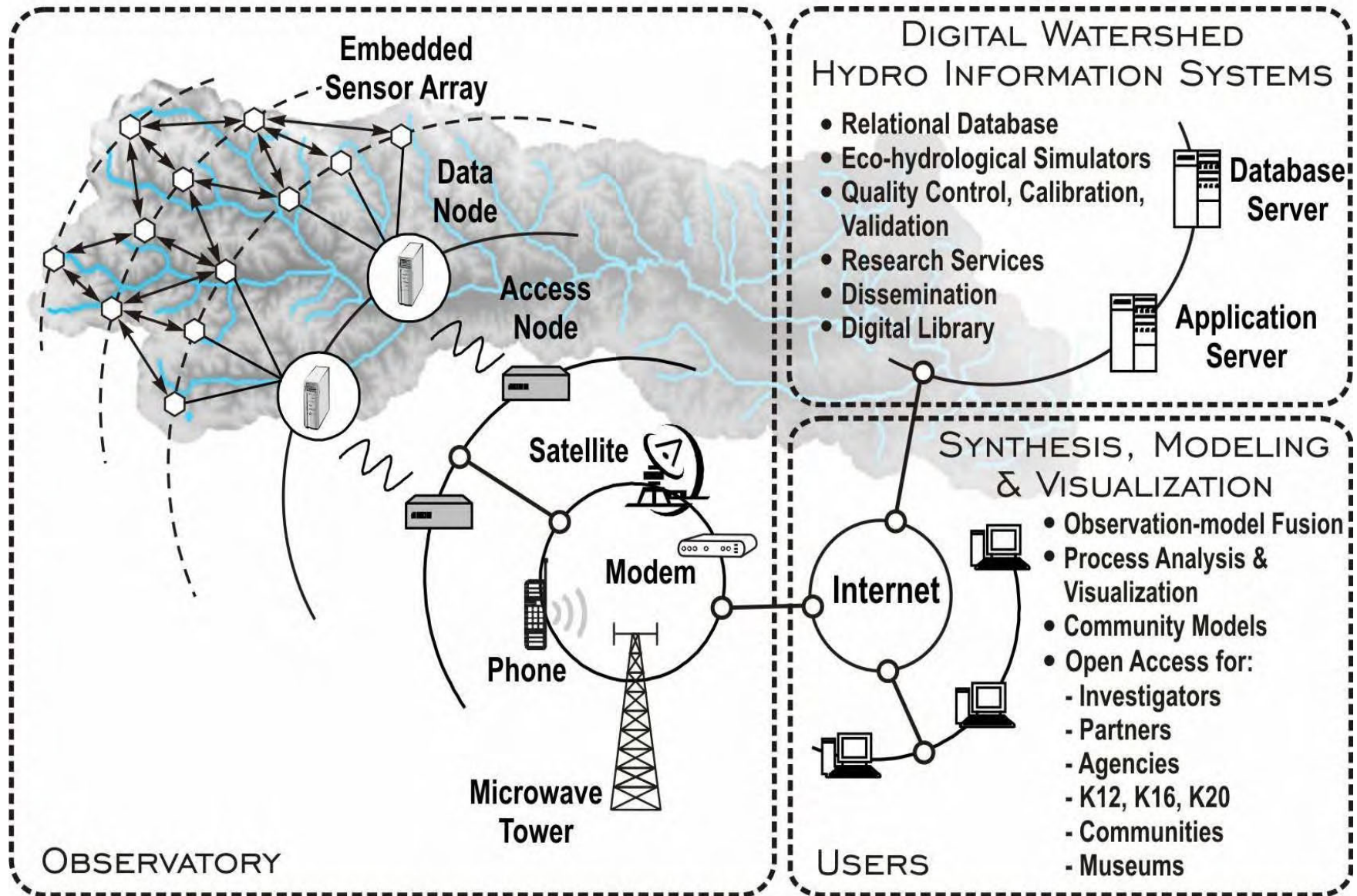
## It is ready!



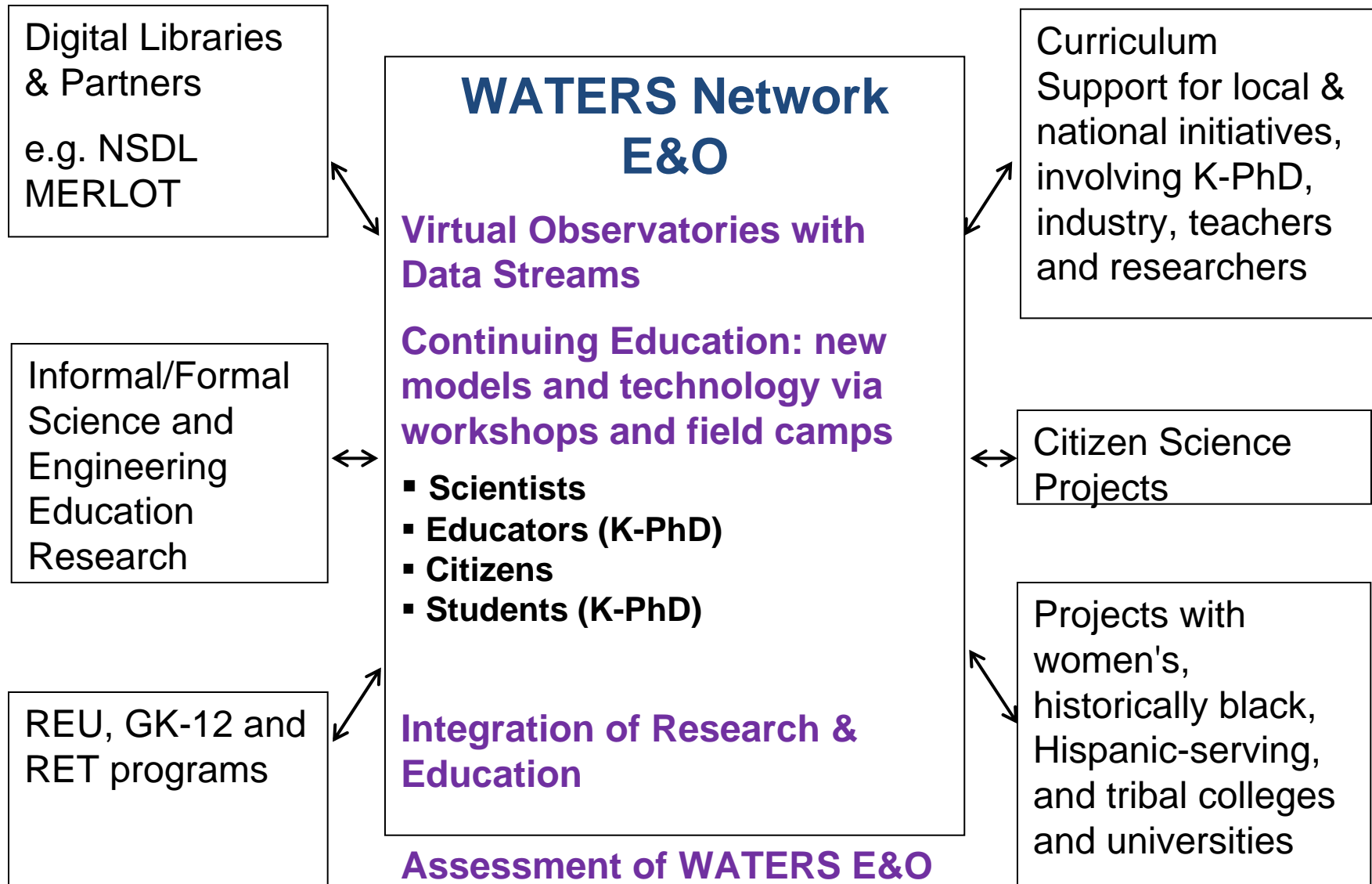
Drawing by Jason Fisher  
UC Merced/WN/CENS-UCLA



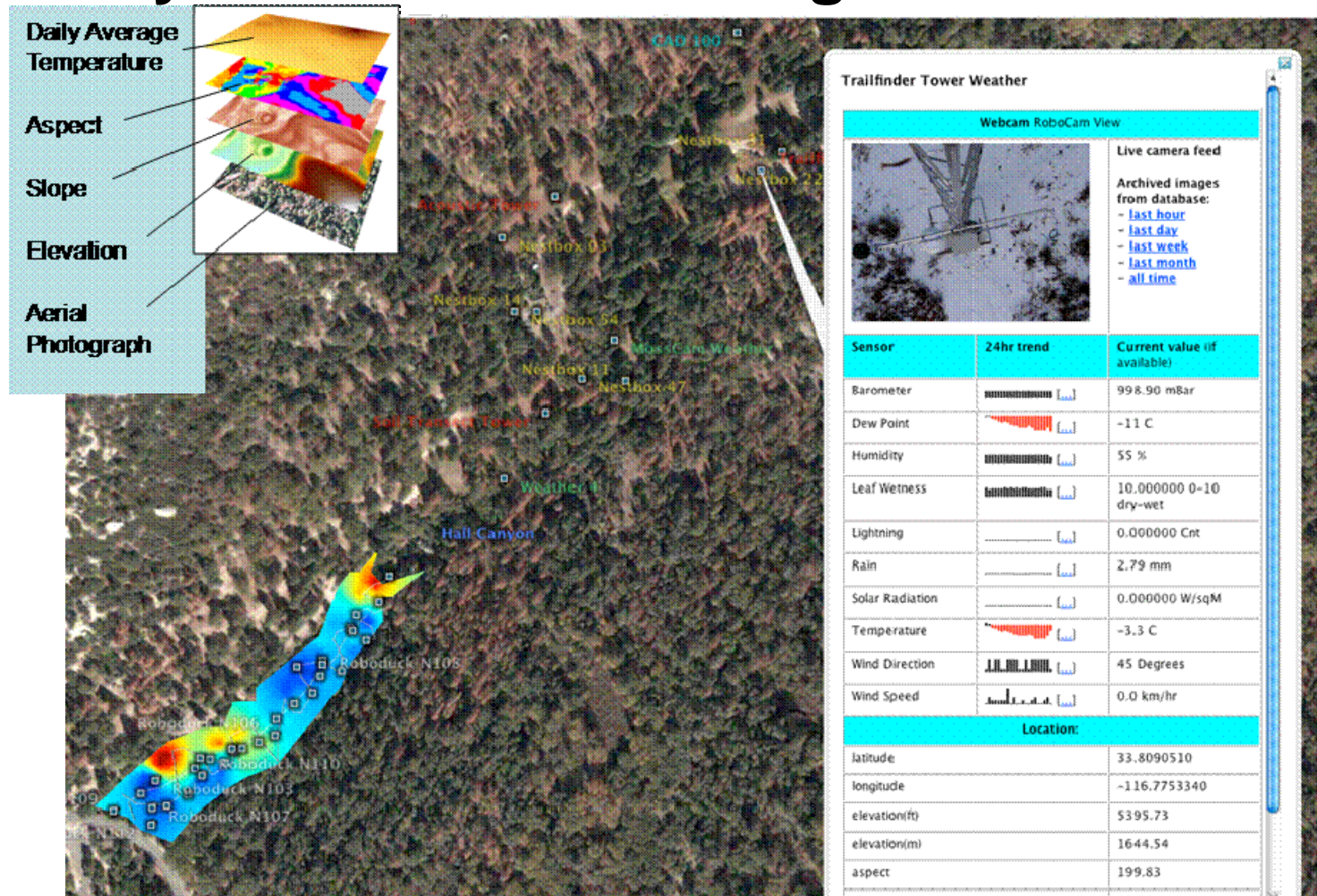
# WATERS Network Cyberinfrastructure



# WATERS Network Education & Outreach will develop partnerships & leverage existing programs.



# WN Virtual Observatories will make observatories remotely accessible to a range of users.



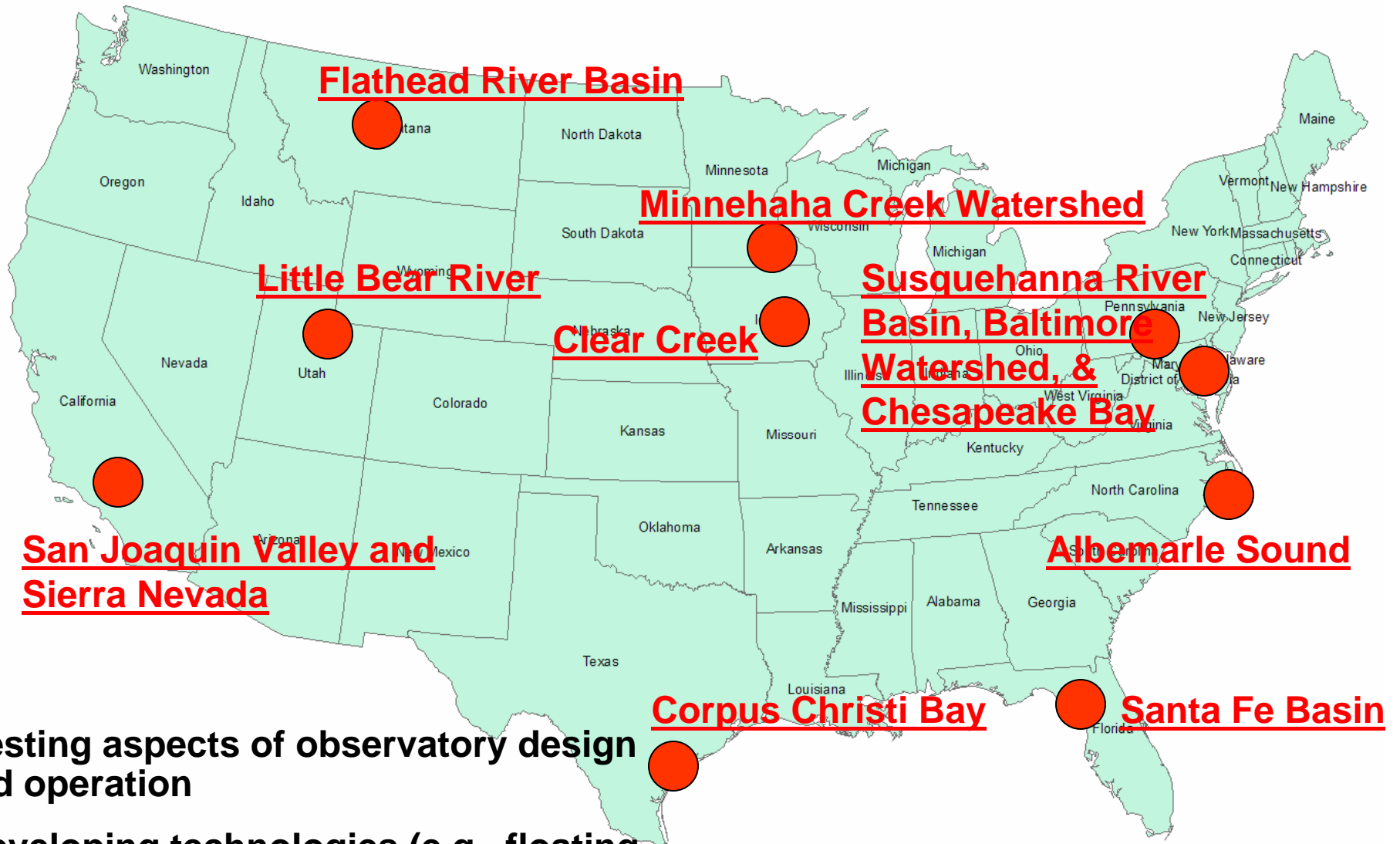
WN E&O would be heavily involved in defining virtual observatory functionality and tailoring capabilities to support all of the types of users.

# Multi-Agency Role in WN

- To date, WN has been an NSF initiative
- To be successful at understanding large-scale water systems, WN must become a multi-agency initiative (Federal, state, local)
- Mission agencies have
  - Common research interests with WN
  - Needs and expertise that can support strong:
    - Problem-driven basic research
    - Research-driven problem solving
  - Extensive existing facilities and data collection efforts that must be leveraged



# WATERS Network Testbed Sites



- Testing aspects of observatory design and operation
- Developing technologies (e.g., floating sensors & real-time sensing systems)

## ***Conceptual Design and Development of a Prototypical Chesapeake Bay Environmental Observatory (CBEO)\****

A *CLEANER*-Initiated Project supported through NSF's CEO:P Program  
(Cyberinfrastructure for Environmental Observatories: Prototypes)

- Integration of many large data sets and *archived model results* related to Chesapeake Bay water quality
- Analysis tools to use the disparate data sets together to address science and management questions in new ways
- Educational tools and data for public and educational uses
- Incorporated into an environmental observatory network (EON) -- prototype project toward WATERS Network

\* UNIVERSITY of DELAWARE, Dominic DiToro, Director; JOHNS HOPKINS UNIVERSITY, William Ball, PI, Assistant Director; UNIVERSITY of MARYLAND, Mike Kemp, Laura Murray; HAMPTON UNIVERSITY, Benjamin Cuker; DREXEL UNIVERSITY, Mike Piasecki; SAN DIEGO SUPER COMPUTER CENTER, Ilya Zaslavsky; CHESAPEAKE RESEARCH CONSORTIUM, Alexey Voinov

# The **CBEO Project** has a close working relationship with **U.S. EPA's Chesapeake Bay Program Office (CBPO)**



## **Chesapeake Bay Watershed**

map courtesy of  
EPA Chesapeake Bay Program

<http://www.epa.gov/Region3/chesapeake/>

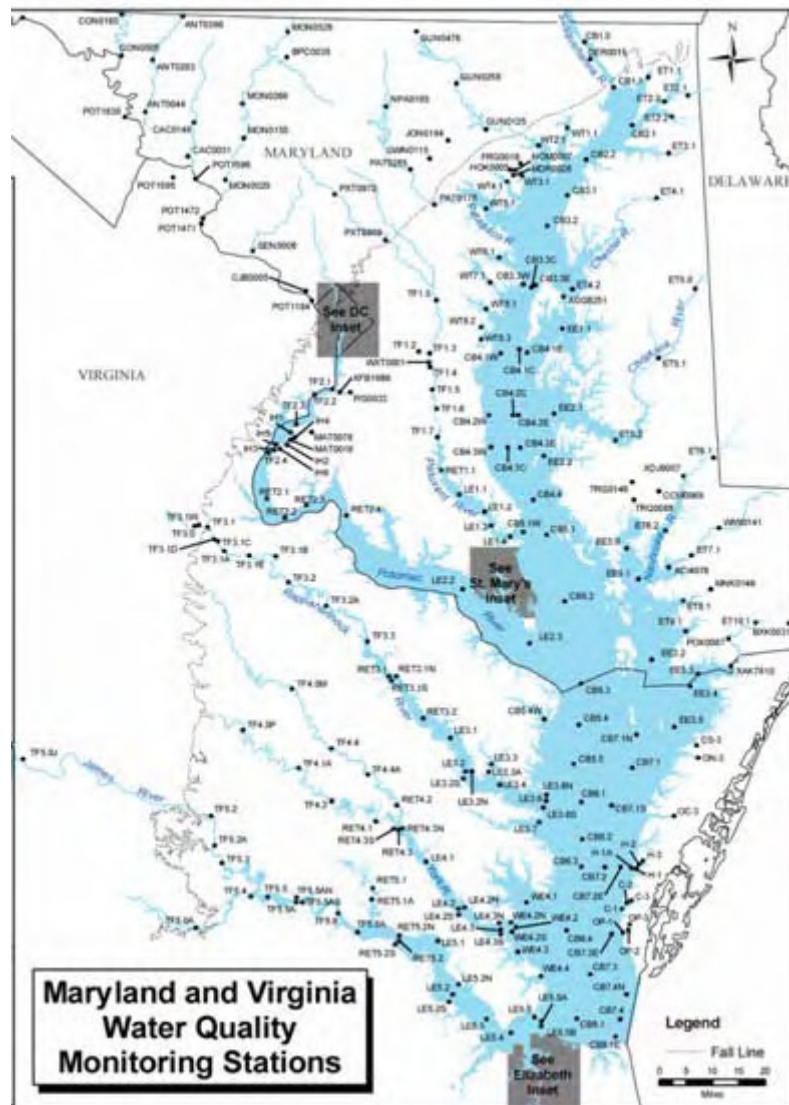
**EPA's CBPO** represents the Federal government in the implementation of strategies to meet restoration goals of the Chesapeake Bay Program.

### **The Chesapeake Bay Program (CBP):**

<http://www.chesapeakebay.net/>

- **A unique regional partnership that has led and directed the restoration of the Chesapeake Bay since 1983.**
- **Partners:**
  - **Maryland**
  - **Pennsylvania**
  - **Virginia**
  - **District of Columbia**
  - **Chesapeake Bay Commission** (tri-state legislative body)
  - **the U.S. EPA**
  - **participating citizen advisory groups.**

## EPA's CBPO is working with the CBEO to integrate data from the Chesapeake Information Management System (CIMS) into the CBEO Test Bed

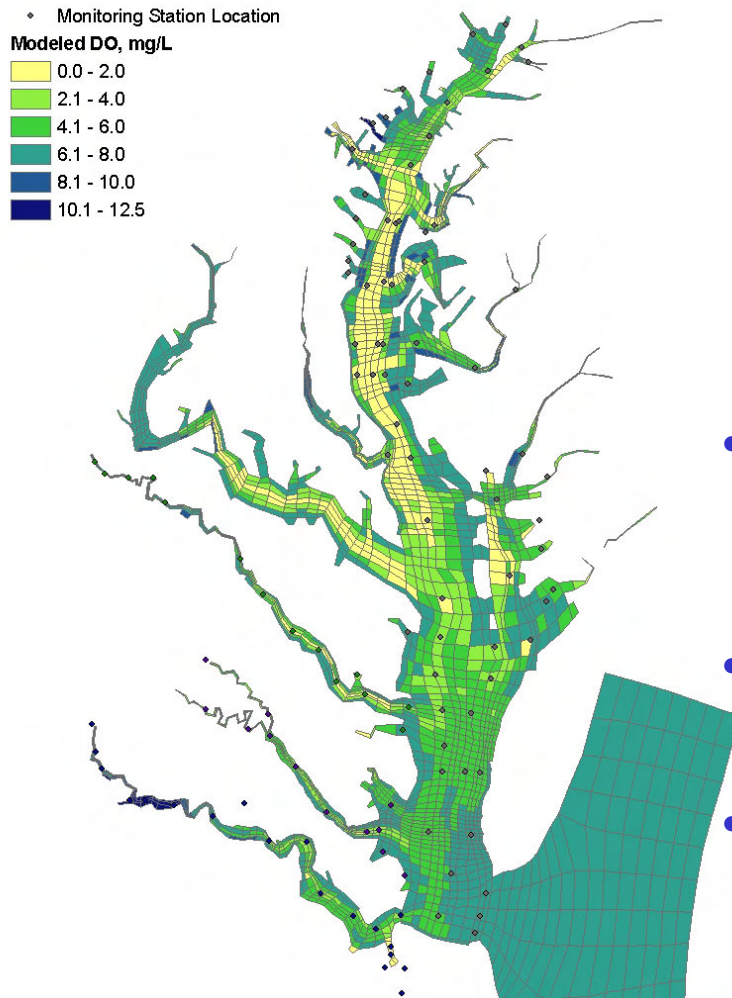


- Extensive data collection;
  - Fixed station monitoring @ 2-4 wk
  - Research data at finer spatial scales;
- CBP monitoring at over 100 stations in main stem and tributaries;
- Vertical profiles in deep & shallow water
- CBP monitoring initiated in 1985 through present with few changes;
- **The CBEO Project is integrating CIMS data into its test bed together with other NEW types of data:**
  - **Archived (historical) model input and output data (next two slides!)**
  - **Satellite and research data (including over-flight data, high-res. local data)**
- **The CBEO Project has translated the CIMS data structure to CUAHSI's "Observational Data Model" standard**
  - **Available for use with national network tools, such as HYDROSEEK**



# EPA's CBPO is working with the CBEO to integrate the Chesapeake Bay Hydrodynamic and Water Quality Models (and associated input/output data) into the CBEO Test Bed

## Example Modeled Results: June 1991 **Bottom** DO



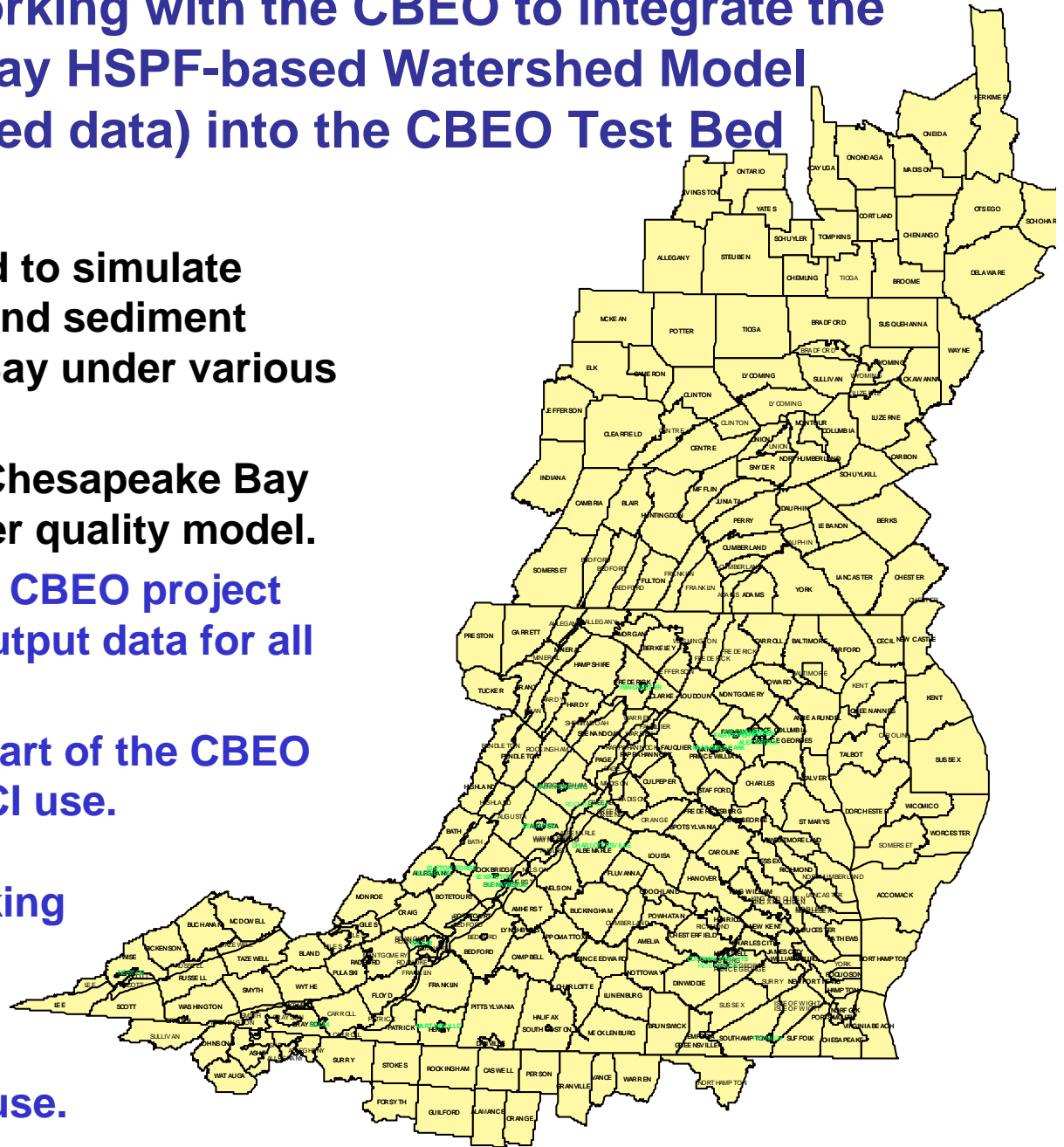
- CBPO contracts the development, calibration, and use of hydrodynamic and water quality models for the Chesapeake Bay through the Army Corps of Engineers' Waterways Experiment Station (WES).

The following 'data' are being stored and archived by the CBEO for network use:

- Archived model input and output for ten years of high resolution calibration runs. (version w/ 13K grid cells);
- New input and output for on-going calibration runs (ver. w/ 55K grid cells);
- A 50-year history of model runs, using consistent input and output data obtained via new runs of the HSPF (4K grid cells)

# EPA's CBPO is working with the CBE0 to integrate the Chesapeake Bay HSPF-based Watershed Model (and associated data) into the CBE0 Test Bed

- 308 land segments
- Painstakingly calibrated to simulate stream flows, nutrient and sediment loads delivered to the Bay under various management strategies
- Serves as input to the Chesapeake Bay hydrodynamic and water quality model.
- CBPO has provided the CBE0 project with model input and output data for all runs from 1984-2005
  - Being archived as part of the CBE0 testbed for shared CI use.
- The CBE0 team is working with EPA's CBPO to compile a new 50-year model run, also to be archived for shared CI use.



# Summary – Why the WN vision requires major investment...

1. Understanding the complex behavior of water & related Earth system processes as coupled human & natural systems requires integrated, coherent observations at multiple scales using **large-scale observatories**
2. Deriving general, place-independent theory & models requires multiple sites with comparable data & controlled design variables to overcome heterogeneity
3. Interdisciplinary research, education, & outreach, particularly for complex systems that require integration, will advance more rapidly when community resources enable multiple individuals to efficiently leverage prior research investments.
4. Will enable significant interagency and inter-organizational collaboration and partnering for addressing the Nation's water resources challenges

