



CINCINNATI, OHIO JANUARY 2006

CONCEPTUAL MODELS AND METHODS FOR DIAGNOSING THE CAUSES OF IMPAIRMENT TO AQUATIC ECOSYSTEMS

Dan Campbell, Naomi Detenbeck, Kay Ho, Robert Burgess, Janis Kurtz, Brian Hill, Marguerite Pelletier, Kenneth Perez, Virginia Engle.
USEPA, Office of Research and Development, National Health and Environmental Effects Research Laboratory (NHEERL)



LTG 2 Poster 03

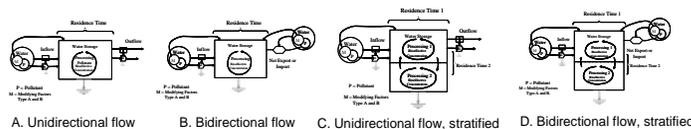
Science Questions

- How are multiple and possibly related causes of biological impairment inferred from observations and cause-effect modeling?
- How does one determine the most appropriate and efficient scale for application of diagnostic methods within the TMDL and 303(d) process?
- What methods and models are needed to diagnose the impairment of aquatic ecosystems due to habitat alteration, nutrients, toxic chemicals, and suspended and bedded sediments?

Research Objectives

- ### Critical Research Objectives
- Construct causal webs using the top-down, bottom-up, and energy systems approaches.
 - Develop methods to determine the scale of regulation necessary to control a given stressor.
 - Develop tools to make a definitive diagnosis of the causes of an observed impairment to an aquatic ecosystem.
 - Develop a set of generic models to explain the effects of stressors on aquatic systems.
 - Develop detailed energy systems models of the actions of multiple stressors that will allow the allocation of impairment among several proven causes.

Research Results



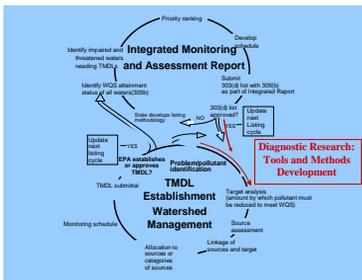
The basic conceptual model includes three elements: Residence time, Type A modifying factors that determine bioavailability, and Type B modifying factors that alter the relationship between the stressor and the response. Four canonical forms of this model are shown above.

Interactions with Customers

Initial meetings with The State of RI DEM and representatives of Region 5 helped us understand the need for our methods and models. This diagnostics research was presented to the Office of Water and to the National Estuary Program Managers in 2004. In 2005, these methods were tested in a meeting with the representatives from several Region 4 states and the SI research group. These contacts with clients have given us confidence that that our tools are needed and will be helpful in fulfilling their obligations under the Clean Water Act.

How Research Addresses the Water Quality MYP Goals

Water Quality (WQ) Long Term Goal 2 seeks to provide the tools to assess and diagnose the causes and pollutant sources of impairment in aquatic systems. This research uses Energy Systems Theory as the theoretical context for the development of conceptual models to explain the mechanisms of stressor action and interaction and differences in the sensitivity to stressors among aquatic systems. The methods used in Toxicity Identification and Evaluation (TIE) are modified and expanded to develop general diagnostic tools to make definitive diagnoses of the causes of impairment to aquatic ecosystems. The tools developed here will be made available for use by the states, tribes, and regions through the CADDIS web site.



The Diagnostics Research Program is providing tools to implement the critical link in the Office of Water's Consolidated Assessment and Listing Method (CALM) between listing a water body as impaired and implementing a Total Maximum Daily Load (TMDL) or other regulatory program that will result in successful restoration.

Research Methods & Collaboration

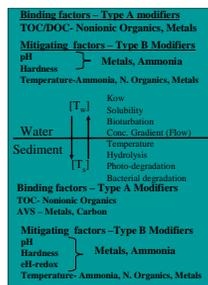
Research Methods

- Top-down and bottom-up causal webs using the EMAP approach.
- The research methods of TIE are used to develop a method and tools for the diagnosis of impairment.
- Narrative descriptions as a method for building world models of stressor action.
- Development of an Energy Systems Models (ESM) of the factors controlling the exposure-effect relationship.
- Construction of complex causal network ESM models to allocate among several proven causes of impairment.
- Landscape flow analysis to determine the scale of control for a given stressor.

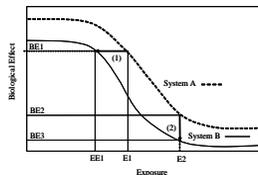
Collaboration

NHEERL diagnostics research has been carried out as a cross-divisional effort from its beginning in 2001. During 2002 and 2003, research on classification and conceptual models was carried out. In 2004, a case study was begun at AED, to develop diagnostic tools for estuaries. Watershed classifications for all EPA Region 5 states are being produced in support of nutrient criteria development in streams. During the past two years the Diagnostics Work Group has had several meetings with the Stressor Identification (SI) research group to compare methodologies and discuss similarities and differences in approach.

Research Conclusions & Future Directions



Conceptual model of factors that affect the availability of toxic chemicals in the water and sediments used to develop the energy systems model (not shown).



Normalization of the exposure-effect relationship by adjusting both the x and y axis. (1) Type B modifying factor shifts the response variable on the exposure axis. (2) At a standard exposure, different levels of the biological effect variables characterize aquatic ecosystems of different kinds.

How Research Contributes to Outcomes

When completed, the diagnostic tools and energy systems models or causal networks developed in this research program will provide powerful tools to identify the causes of impairment in freshwater, estuarine and marine ecosystems for use within the CADDIS system currently being promulgated by the USEPA. This information is crucial to fulfilling the responsibilities of the states and tribes under the Clean Water Act and to making informed decisions on environmental policy.