Muskegon Futures:

Mega Model Forecasting

Muskegon Watershed Research Partnership Volume I

Overview: The Muskegon Watershed Research Partnership

In August of 2000, approximately 50 researchers in the field of ecosystem analysis and watershed management met with nearly 50 stakeholders, members of philanthropic organizations, and government officials. Over a four day period all participated in a workshop specifically convened to consider the current health and future sustainability of the Muskegon River Watershed. The attendees literally laid out on the table what was known about the Muskegon River system, identified gaps in this existing information, reported on current problems, and began to speculate about the watershed's future. Following four days of intensive discussion, the first Muskegon River Watershed Research Summit came to a close and a comprehensive action plan began to emerge. Many of those attending this pivotal meeting came away with specific ideas about how they might contribute to a better understanding of those issues that are, or will soon become priorities in the Muskegon River Watershed.

Working together, stakeholders and researchers argued, advocated, and by the end of the August 2000 Summit had proposed several new large multi-university research projects. The Muskegon Watershed Research Partnership (MWRP) was born. The Wege Foundation stepped up to support the acquisition and interpretation of land use and cover data throughout the watershed, the first comprehensive analysis of its type since 1978. The Great Lakes Fishery Trust (GLFT) supported an extensive study characterizing ecosystems and fishery habitats throughout the lower portion of the watershed. And the GLFT funded the most comprehensive assessment of a watershed in this state's history. The Great Lakes Protection Fund helped fund a study of the relationship between high quality environments and economic vitality. Data depositories were created, an information/education program was implemented, and a book was written (Jeff Alexander's "The Muskegon River: The Majesty and the Tragedy of Michigan's Rarest Rver",2006) as a way to convey what was happening and to stir up interest in protecting the Muskegon River's future.

Today the MWRP continues as an interacting group of scientists, representatives of various watershed and environmental organizations, and a patchwork of current and former funders who have invested in the Muskegon River's future. A much strengthened Muskegon River Watershed Assembly now plays a central role in facilitating these interactions and promoting an integrated approach to the Muskegon River's sustainability.

The Muskegon River

At 219 miles long, the Muskegon River is the second longest river in Michigan. The drainage basin encompasses 2,724 sq. mi. (7,057 sq. km.) and is slightly larger than the state of Delaware . Head waters include Higgins and Houghton lakes, from which the river flows southwest eventually becoming Muskegon Lake, which in turn drains into Lake Michigan via a one mile long channel. The river drops a total of 575 feet from its headwaters to Lake Michigan and has approximately 94 tributaries that flow into it . The watershed contains 151 Minor Civil Divisions. The Native American name "Muskegon" refers to the rivers' extensive riparian wetlands..."the marsh place"

Inside this issue:

What is the Muskegon Mega Model?

From the beginning participating scientists agreed that it was not possible to physically measure everything needed to address the known problems, much less new issues that would undoubtedly come up during the investigation. Many of those involved also felt it was essential to find a way to boil down our best scientific understanding about how the Muskegon River Watershed worked so that if could be more easily shared with the wide variety of local leaders and stakeholders who ultimately make local and regional decisions. Furthermore, everyone was in agreement that it is always easier to prevent problems than it is to try and fix them later, especially when those problems involve water pollution, ecosystem degradation, and habitat destruction. So in response the idea of building a summary ecosystem model to make ecological forecasts of the consequences of alternate management choices arose naturally at the first Summit.

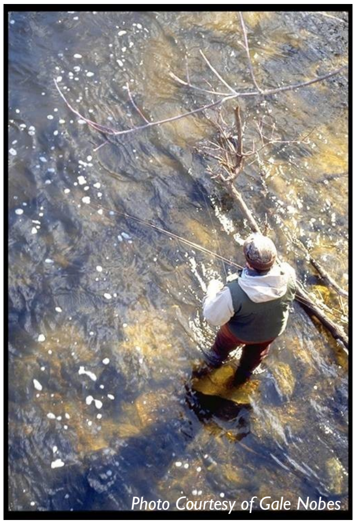
Photo Courtesy of Gale Nobes

In subsequent discussions this summary model was referred to as the Muskegon "Mega Model" that would be used to integrate and interpret existing and newly planned investigations, and to vet potential strategies for ensuring the river's future. Eventually, the model was formally named the **Muskegon River Ecological Modeling System** (MREMS), but the original name, Mega Model, is the one that most participants remember. Principal science partners originally involved in the creation of the Mega Model Project included the University of Michigan, Michigan State University, Grand Valley State University, and MDNR's Institute for Fisheries Research. This partnership has since expanded to include researchers at Purdue University, at SUNY-Brockport, and NOAA's Great Lakes Environmental Research Laboratory. Goals for the Mega Model project, as originally proposed to the Great Lakes Fisheries Trust (GLFT) included:

1) Development of a new integrated watershed model that can serve as the basis of discussion, hypothesis testing, and further research development;

2) A formal risk assessment that examines relative severity of important problems facing the watershed such as urban sprawl, sedimentation, and impoundment;

3) A linkage of process-based models with empirical data sets and ecological service assessment, and;

4) A number of public-oriented tools and modeling products.

Almost eight years later, there have been numerous spin-off studies initiated, completed, and published: including many academic journal articles, book chapters, theses, and dissertations. However, the MWRP public information bulletin series "Muskegon Futures:", of which this is the first installment, best represents our attempt to meet the public outreach goals and spirit of the Mega Model project. Through these brief publications the project investigators hope to provide summary information that links results of technical science focused on a wide variety of topics to the practical and very real issues facing the Muskegon River watershed, now and in the not too distant future.

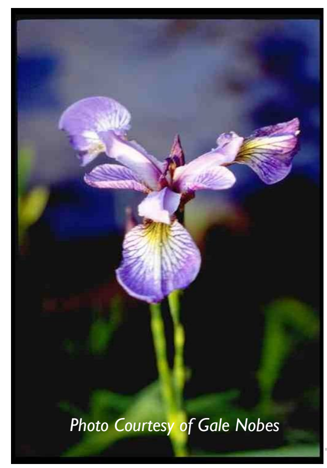
Photo Courtesy of Gale Nobes

Stakeholder Organizations

A requirement that the GLFT placed on each of the special Muskegon River proposals it entertained, was that it be the joint proposal of both University scientists, and regional stakeholders who represented the interests of all those who depend on the Muskegon River's future: the people who live, work, or recreate in its watershed. Participating in the development of the original Mega Model proposal, and in subsequent stakeholder conference meetings in 2002, 2003, 2004, 2007, and 2008 were representatives of the following organizations:

The Muskegon Watershed Assembly
Michigan Department of Natural Resources
Michigan Department of Environmental Quality
Consumers Energy
Trout Unlimited
Brooks Township
The Land Conservancy of West Michigan
Timberland RC&D
The Lake Michigan Federation
The Michigan Lakes & Streams Association

Watershed Stakeholders Set the Ecosystem Modeling Agenda

Scientists enjoy building models because… that's just what scientists do. But what kind of models? Designed to answer what kind of questions?

The role of the Stakeholder groups in the Mega Model project was to specify which questions the science team should be trying to answer about the future of the Muskegon. In June 2002, representatives of 13 watershed and environmental organizations met at GVSU's Annis Water Resources Institute in Muskegon with project investigators to lay out specific questions and resource management issues towards which model building and calibration could be aimed. Weighing both the nature of practical concerns they had regarding the watershed's future sustainability and descriptions by the project scientists of what was realistically achievable and what was not, the group settled on 3 major areas of focus:

1. Land use Management
2. Erosion Management
3. Dam and Hydrologic Management

Building on this framework the group labored together to propose a series of explicit scenarios (imaginable future management actions or policies) which could be evaluated with the developing MREMS system. Given a target of 3-4 scenarios per area of focus, instead we walked away at the end of that long day with 37 management scenario to evaluate!

Intervening discussions, new information, and lack of resources has whittled the list down to an essential 19 scenarios that have been completed to date. These include:

- 4 major land use scenarios representing different strategies and commitments to limiting urban development, forest growth, and agricultural preservation.
- 3 different riparian buffer (set-back regulation) scenarios applied to each of the baseline urbanization scenarios (total of 6).
- A series of 11 historical and back-casting scenarios to estimate river condition and function from 1830 to 1998.
- One main stem dam removal scenario.
- Researchers themselves have added a climate change scenario which is in the process of being completed.

Can You Trust a Computer Model?

Some people distrust all computer-based modeling, other people take every prediction to be hard scientific fact. What are ecological forecasting systems like MREMS good for? How right or how wrong can they be?

MWRP scientists have done their best to carefully test and validate the model components of MREMS. And by objective standards these models accurately reproduce current conditions given current inputs. But of course no one can validate model predictions about the future without a time machine. It is important , therefore, not to take any specific prediction of these models too seriously. But, it is equally important use and not to summarily dismiss them. Computer model forecasts of complex real world systems like rivers are bound to be wrong in many of their specific details. The goal of modeling for ecosystem management is not absolutely perfect , detailed prediction. Instead the goal is to systematically gather together what is known about how the an ecosystem "works", and then construct a useful simplification for discussion and further testing. Scientists, by building models based on the best available scientific theory and relevant data, hope their models will mimic the essential behavior of the system they represent. If a model faithfully represents fundamental processes, then we can study the way it responds to various changes and perturbations (management scenarios in our case) and infer something about the way the real system will behave. Testing a small model of a new airplane in a wind tunnel provides a useful indication of how the design will fly when built. But it isn't a substitute for flying the real plane with a test pilot. Models never really prove anything about the future (or the past for that matter). They only suggest. But given the many challenges facing the Muskegon watershed, we need suggestions now in order to rationally plan for the future.

Principal Models

LTM2
ILHM
HEC_HMS
HEC_RAS
SRTM+
MRI_LOADSV2
MRI_DOMQ
MRI_BIOASSESS
USGS GLGAP_fish
SHMUSK

Principal Modelers

Land Cover
Bryan Pijanowski
Deepak Ray
Jonah Duckles

Hydrology
David Hyndman
Anthony Kendall
Paul Richards
Martha Carlson
Mike Wiley

Hydraulics
Mike Wiley
Matt Ladewig
Catherine Riseng

Temperature & Loads
Su-Ting Cheng
Matt Ladewig
Mike Wiley

Biology
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Ed Rutherford
Jeff Tyler
Paul Steen
Paul Seebach
Mike Wiley
R. Jan Stevenson

Project Leaders

Mike Wiley
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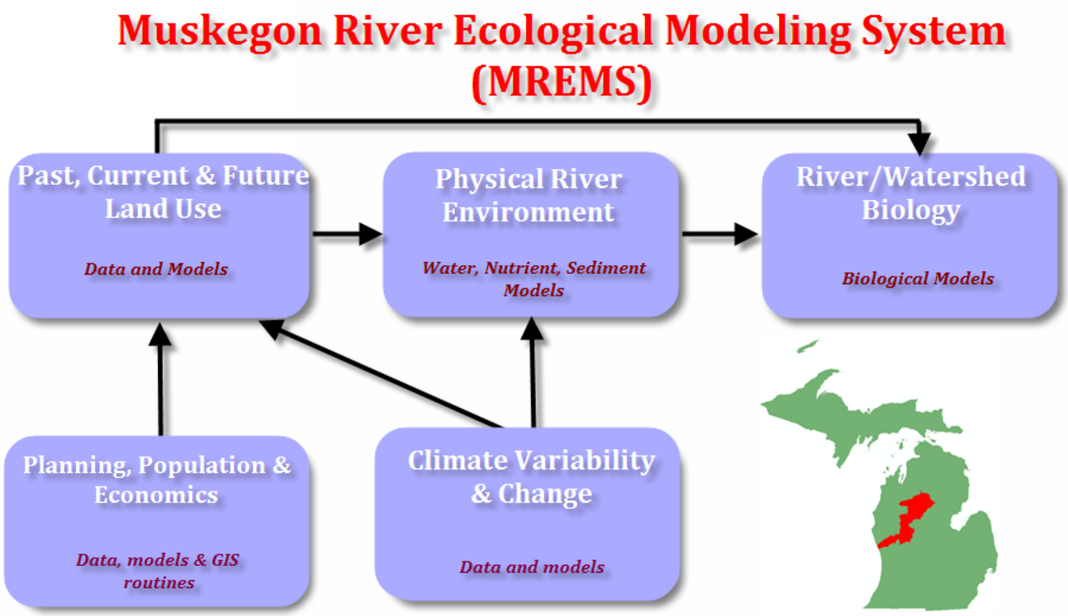
How the Mega Model Works



The Muskegon River Ecological Simulation Modeling System (a.k.a. the Mega Model) is technically best described as a “multi-model”. That is, it is really a large set of independent models that treat various aspects of the Muskegon River ecosystem, but which are synchronized by shared inputs from climate, land cover, and river network models. Geo-referenced data exchange protocols help models operating at different spatial and time scales to communicate and integrate outputs. For a typical biological prediction, output from 5-10 different models executed by working groups at different universities are integrated to produce a single prediction. For example to evaluate the effect of a Farmland preservation scenario on the growth rate of young Steelhead, output from the following sequence of model runs is required:

1) **Land Transformation Model (LTM2) at Purdue University to produce the land cover patterns for the future;**

2) **The Standard Climate Model at MSU to provide detailed rain, temperature, and radiation inputs;**

3) **A distributed landscape hydrology model (ILHM) developed at MSU to redistribute precipitation and snowmelt into evapotranspiration, groundwater recharge, and overland flow based on climate inputs.**

4) **A groundwater model (MODFLOW) at MSU to simulate the flow of water once it becomes recharge until it discharges to surface water bodies;**

5) **A surface water routing model (HEC-HMS) at UM which uses a custom synthetic unit hydrograph model and standard channel routing routines to move water through the river channels systems;**

6) **A temperature model (SRTM+) at UM to predict longitudinal and seasonal changes in water temperature;**

7) **A reach scale hydraulic model (HEC-RAS) at UM to predict daily changes in depth and velocity distributions;**

8) **A spatial habitat and benthic biomass model developed by UM to describe substrate and food availability; and finally**

9) **An individual based bioenergtic model for steelhead (SHMUSK) run by Fisheries Projections in Connecticut.**

MREMS model executions are, like the whole project, a very collaborative effort!

For more detailed information visit our website at www.mwrp.net/