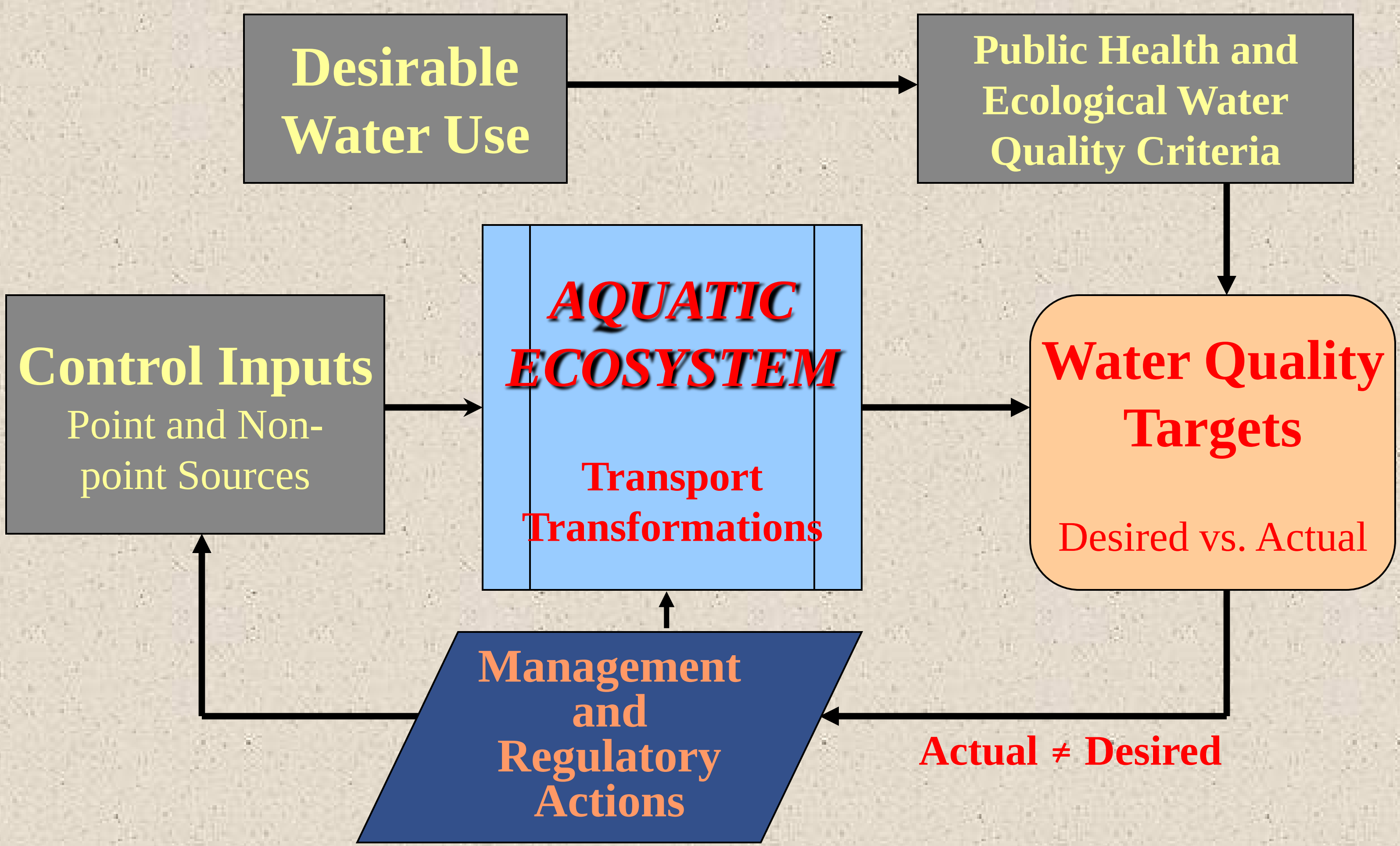
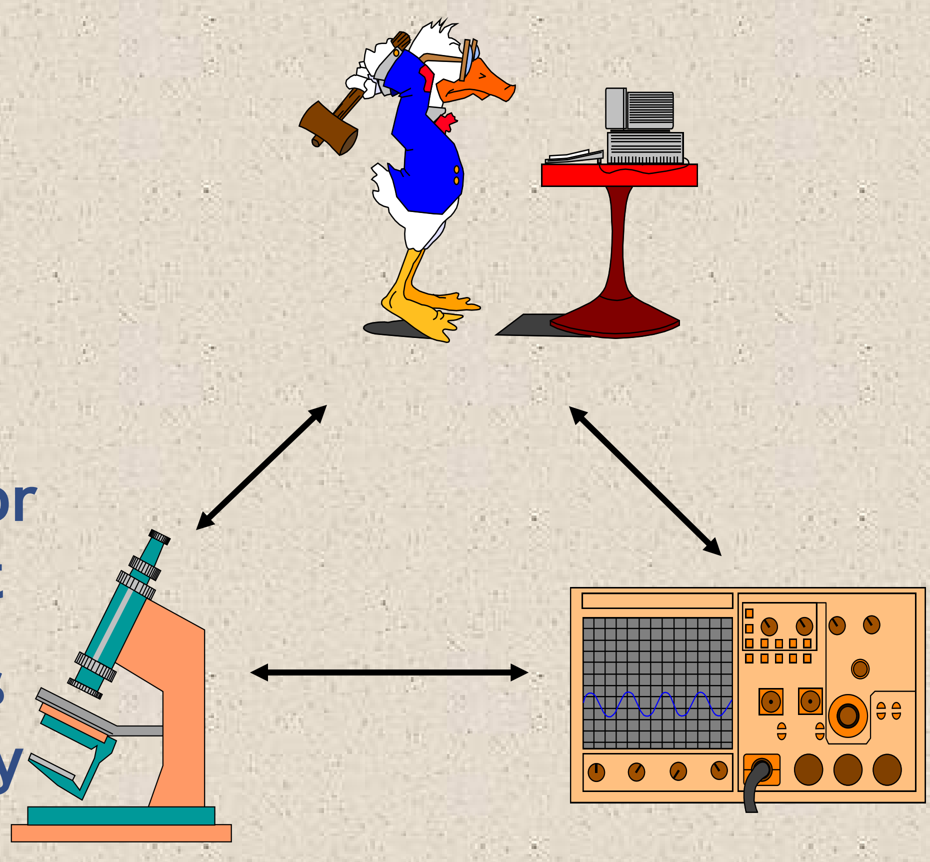
Aquatic Ecosystem Management Flow Diagram



Modeling/Monitoring/Research Symbiosis

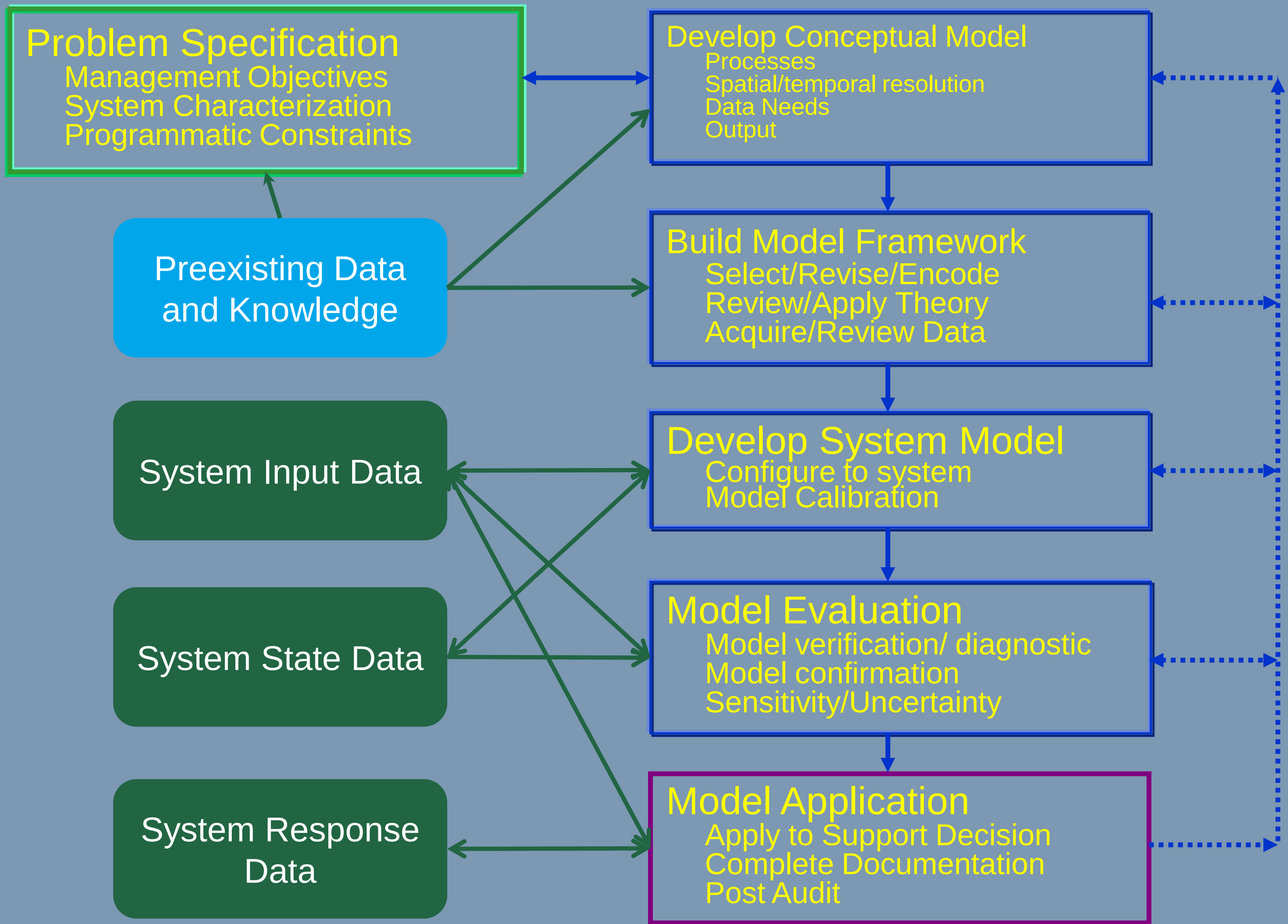
- **Models** provide insight and make projections
- **Research** provides Understanding and parameterization for Model Development
- **Monitoring** provides input and credibility for Models



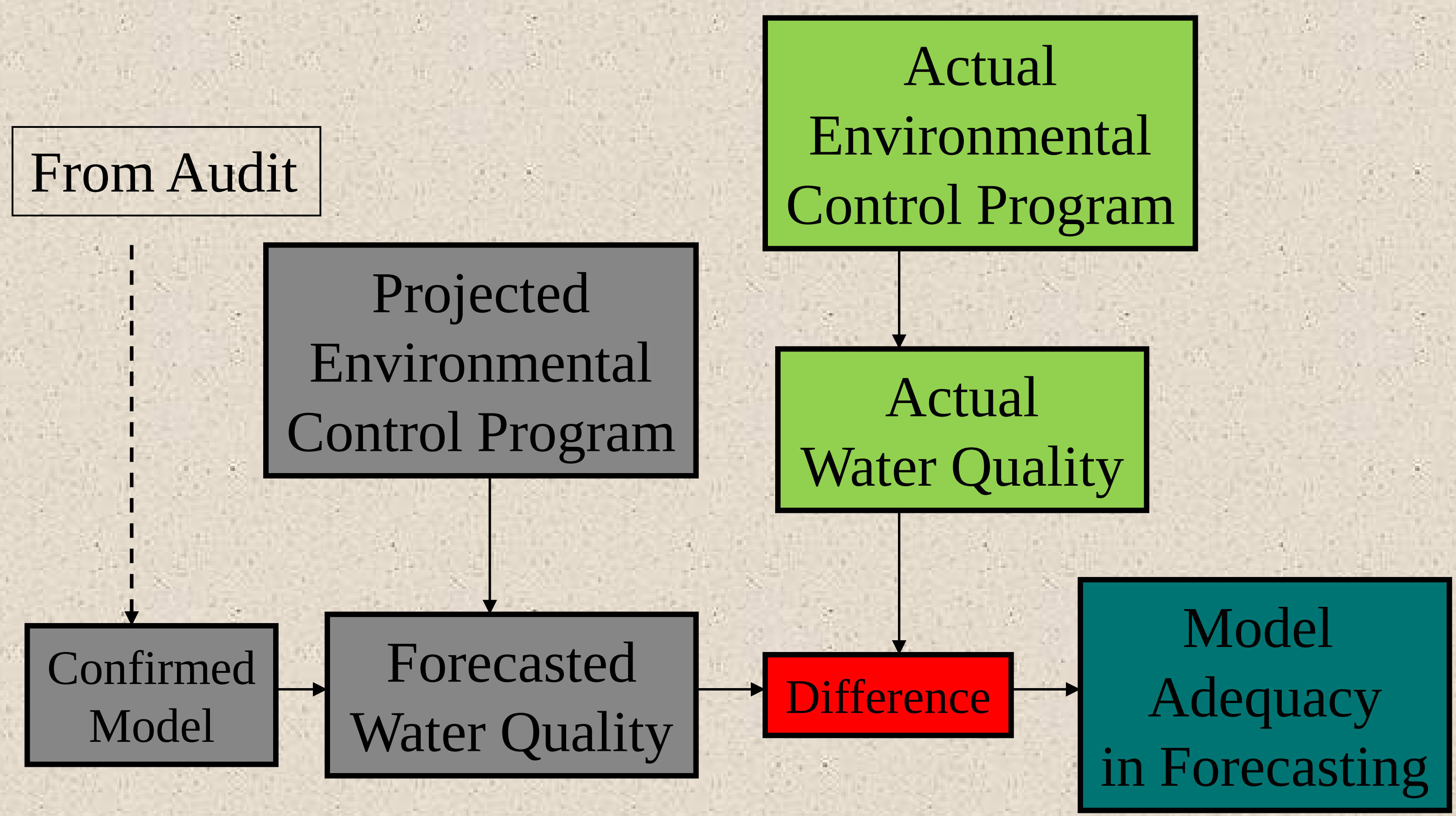
Important Value of Models for Linking Research and Management

- Models provide a means of synthesizing all data available on a site
  - Combine effects of natural processes and contaminant sources to reproduce observable trends
  - Help to build a conceptual understanding of system
  - Help to examine relationships, test hypotheses, and identify gaps or inconsistencies in data
- Models do not create new data but rather must be consistent with all available data
  - Data that represent long-term behavior of the system may be most important "constraint" on models
  - Data that measure process rate and extent are as important in constraining models as data that measure state variables

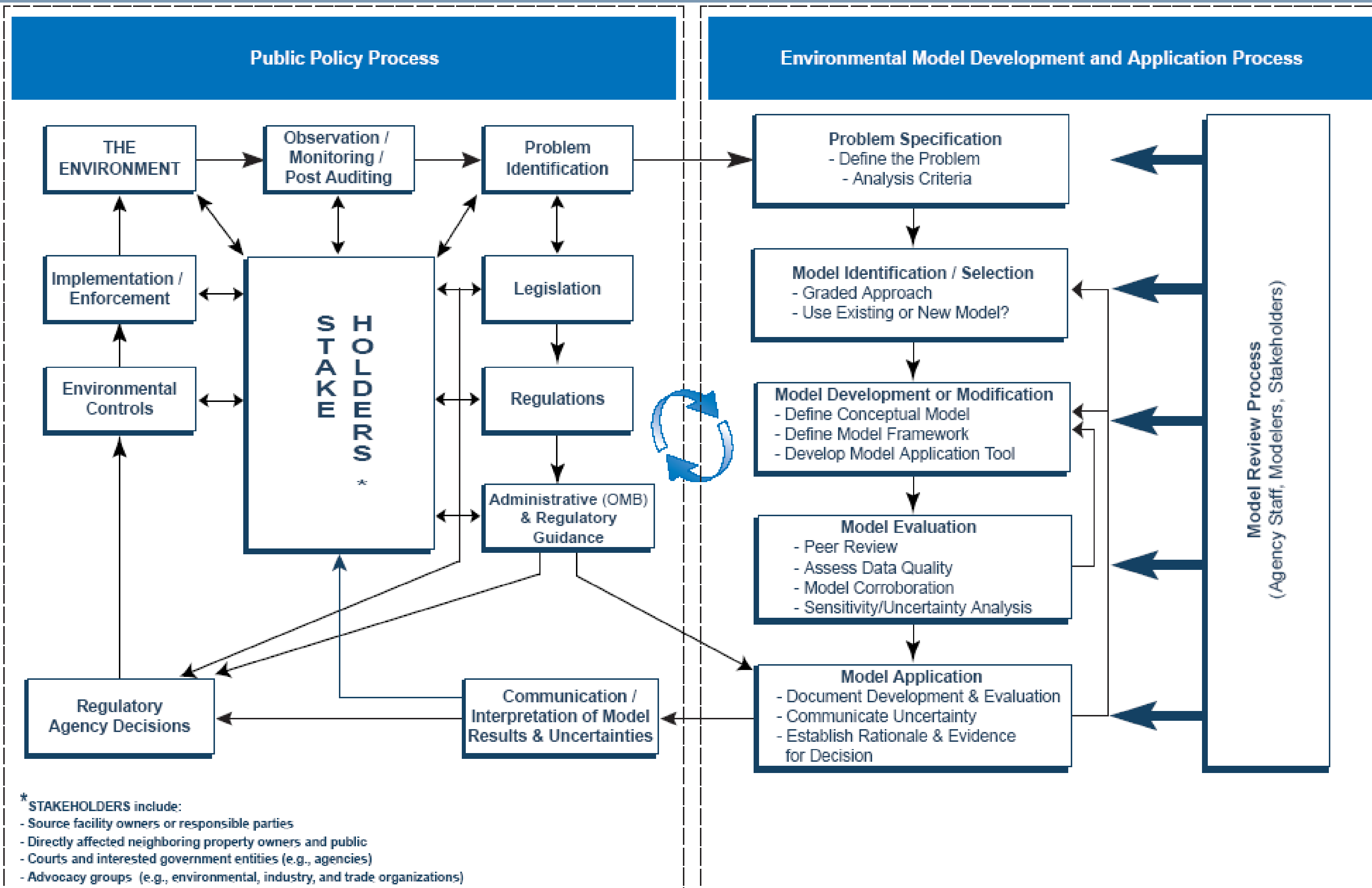
Modeling Process for Management and Policy Decision Making



Post-audit of Models Relative to Environmental Actions

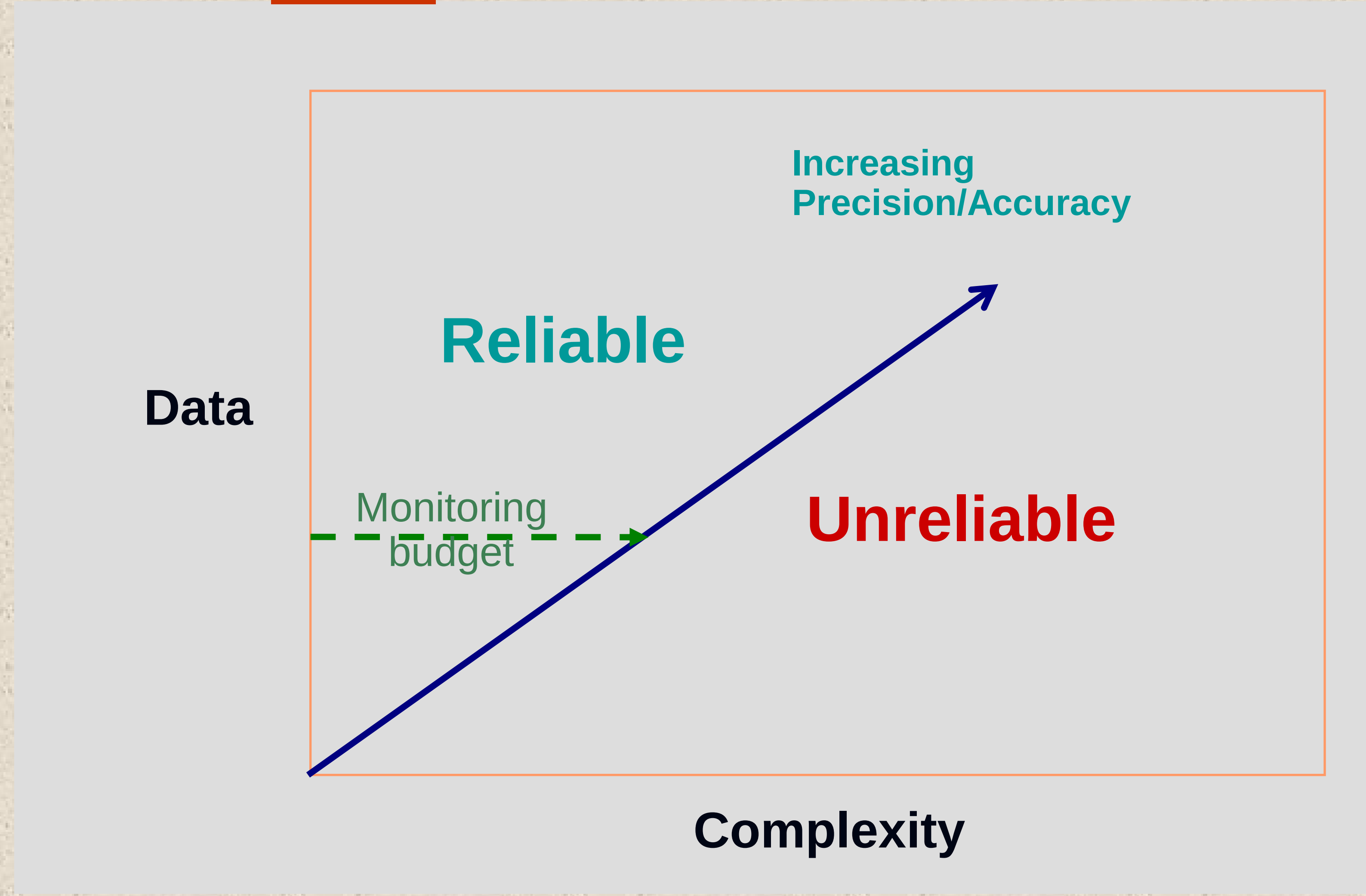


Modeling Interaction with Regulatory Process

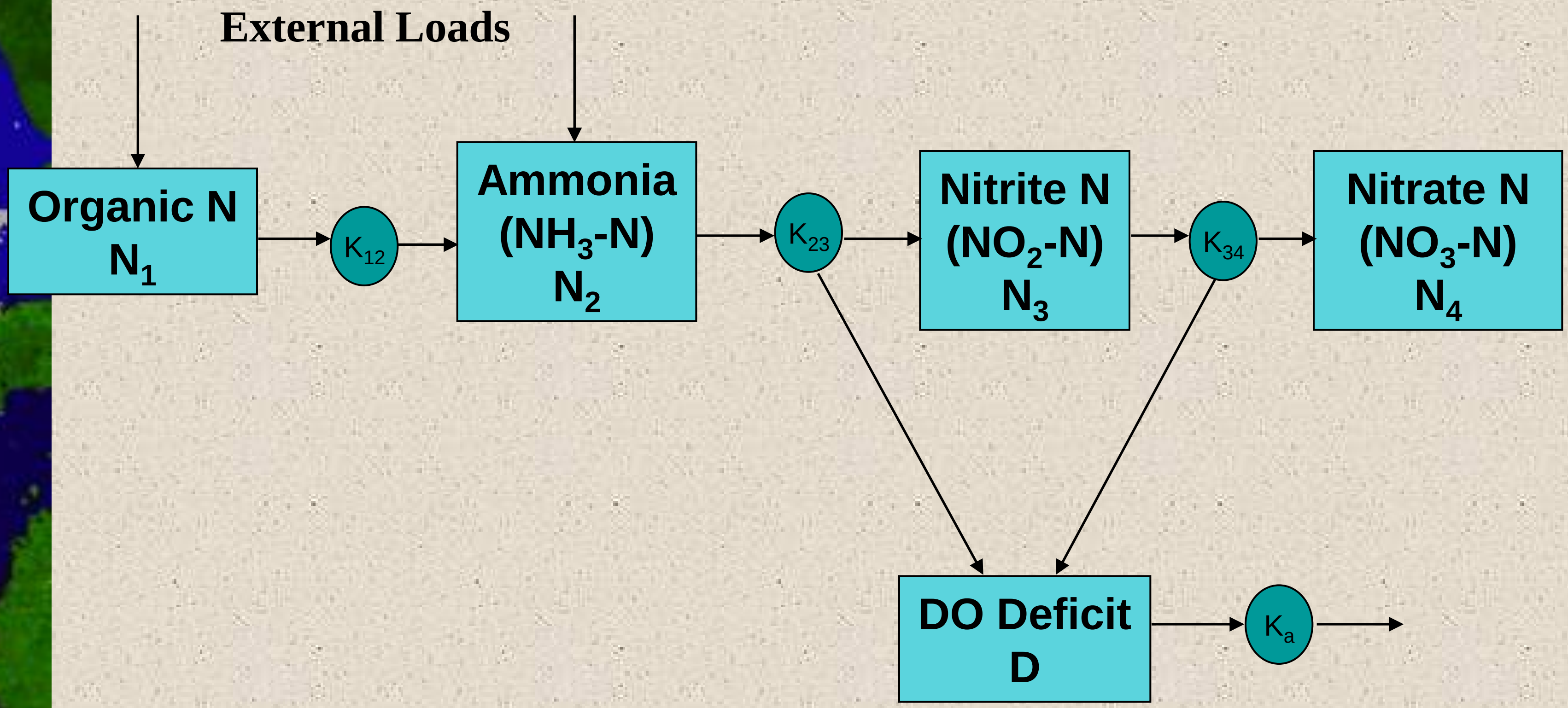


Relationship of data and complexity to reliability

Essential consideration: “A model is only as good as the data available to support it.”

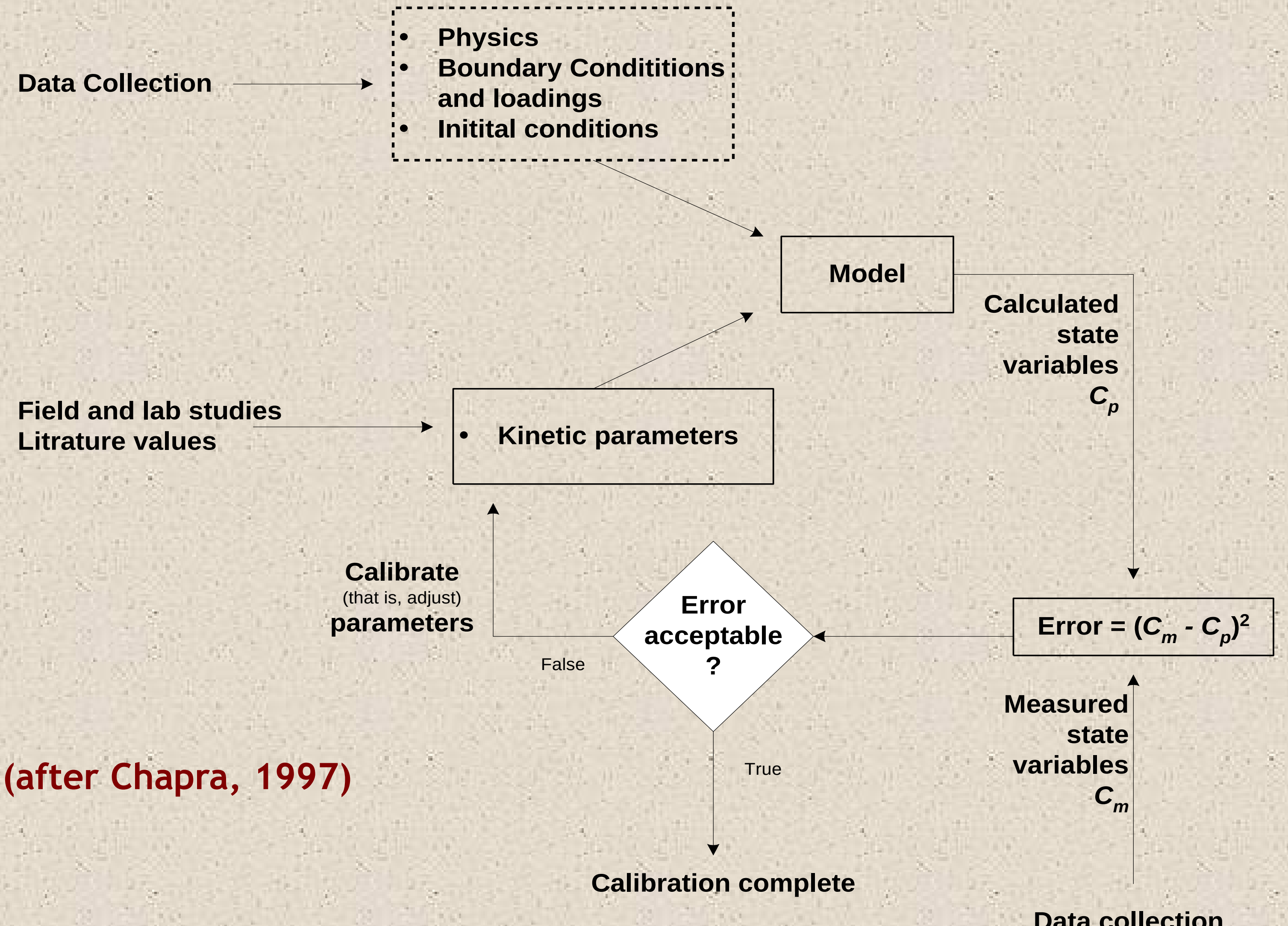


Example Conceptual Model: Affect of Nitrification on Dissolved Oxygen



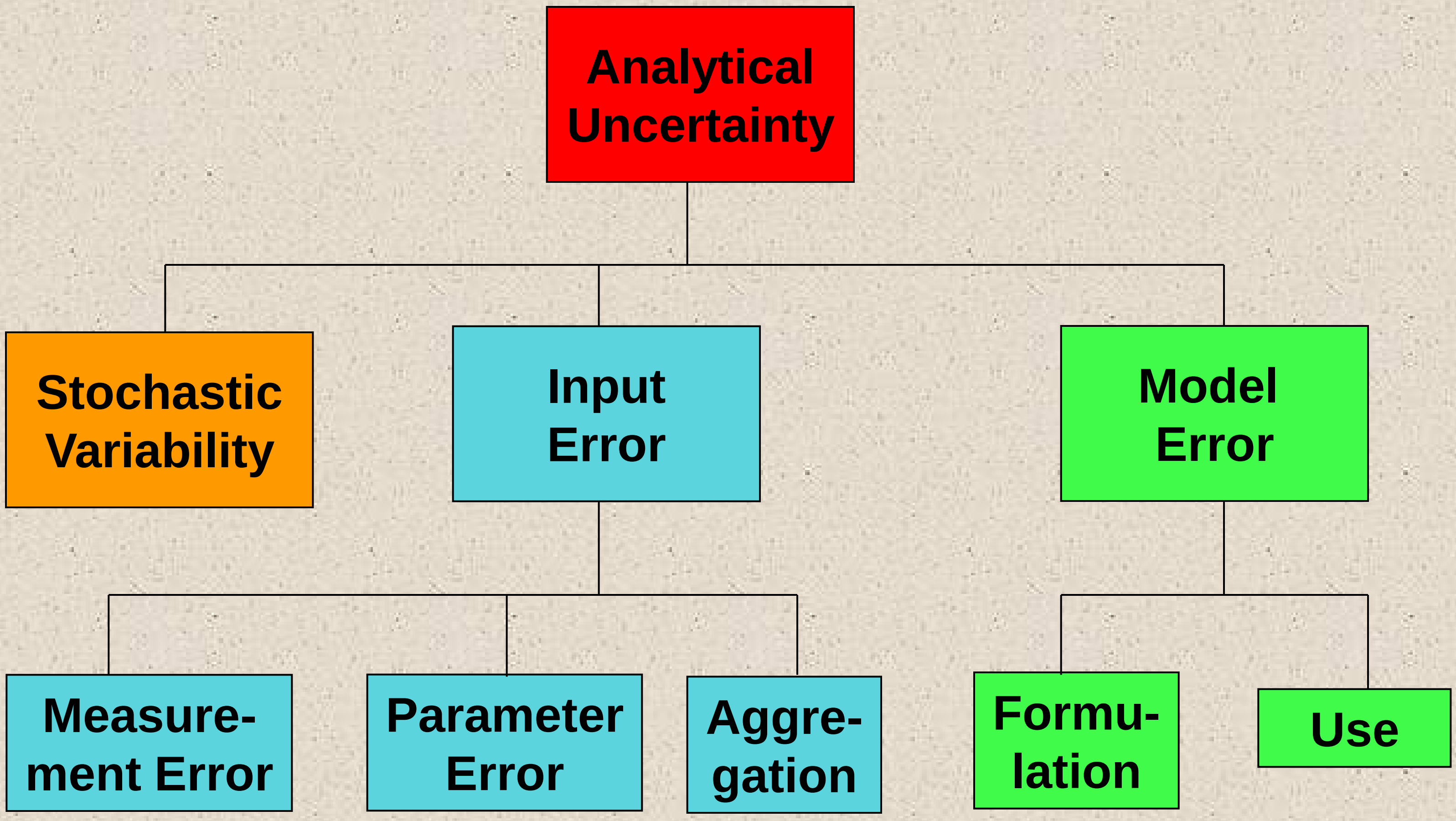
$$\frac{dD}{dt} = K_{23}N_2 + K_{34}N_3 - K_a D$$

Model Calibration Process



(after Chapra, 1997)

Sources of Model Uncertainty



Review Principles for Model Development and Application

- Start simple and build complexity as needed
- Model credibility and acceptance requires rigorous comparison with data
- Model calibration is a scientific process
  - Not just a mathematical “curve-fitting” exercise
  - Should be judged qualitatively and quantitatively
- Try to “confirm” the calibrated model with independent data set
- Post-audit model performance whenever possible
- Develop detailed documentation of the entire modeling process

Utility of Water Quality Models

1. Enhance Scientific Understanding
   - Synthesis of complex systems
   - Identification of gaps in knowledge
   - Direct research and integrate process and field information
2. Water Resource Management
   - Resource evaluation
   - Rational regulatory and remedial policy decisions
     - Protection/improvement of aquatic ecosystems
     - Protection/improvement of human health

Ongoing Peer Review during Modeling Process

Clarify Objectives / Set Goals
↓
Review Available Data and Model
↓
Design Conceptual Modeling Strategy
↓
Recommend Additional Data
↓
Develop Model
↓
Evaluate Model
↓
Apply Model

Ongoing Communication and Review

MPCA Staff

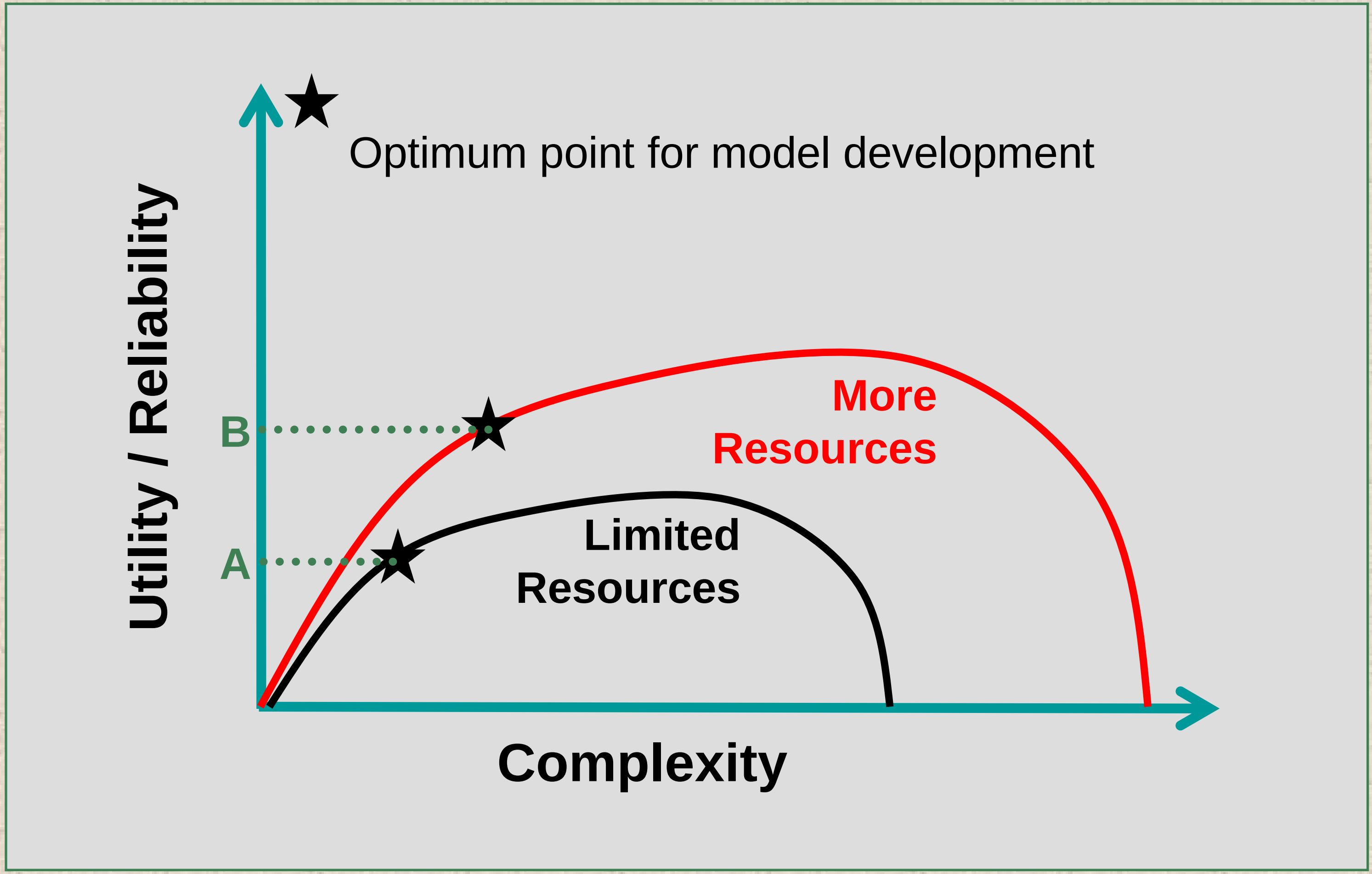
Stakeholder Advisory Committee

Science Advisory Panel

Models Aid in Assessment and Management of Contaminated Sediments

- Provide a means of understanding and forecasting system behavior under “natural attenuation” as a reference.
  - Organizing and explaining field observations
  - Formulating and Quantifying “Conceptual Model”
- Provide a means of comparison of system response to Remedial Options with reference to “natural attenuation” trajectory.
- Provide a means to forecast the impact of extreme events for which there is no actual experience (Permanence? Stability?)
- Provide a means to evaluate and measure the success of implemented regulatory or remedial programs (Post-audit)

Optimum Model Complexity Depends on Problem Specification and Resources Available



Models as Research/Synthesis Tools