

Using Models in Water Management: Philosophy, Principles and Practice



Daniel P. Sheer, Ph.D., P.E.
President, HydroLogics Inc.
March 13, 2013



Presenter

Daniel P. Sheer

June 24, 2002

**HydroLogics, Inc.
Office Locations**

10440 Shaker Dr., Ste. 104
Columbia, MD 21046
410-715-0557

811 Mordecai Dr., Ste. 200
Raleigh, NC 27604
919-856-1288

1851 Heritage Lane, Ste. 130
Sacramento, CA 95815
916-920-1811

Management is about Values

- We manage to achieve the things we want, i.e. to advance our VALUES
- “What do we WANT?” is NOT a scientific question
- “What can we GET by managing” IS a scientific question
- MODELS can help determine what we can GET and HOW we can get it

Management Models:

- Predict the likely **OUTCOME** of human actions
- Produce output that relates the outcome to human **VALUES**
- Use scientific cause and effect or empirical relationships to make the predictions and to produce the output

Management Models vs. Research Models

- Research models try to simulate history in order to determine how the world works
- Management models assume that we know how the world works, and try to evaluate the impacts of actual and potential human actions on the future

Models are “Needy Beasts”

- Models require care and feeding
 - Data
 - Methods
 - This must be provided
- Models need the ability to simulate different kinds of human behavior
 - Users can't give this to models – they have to be born this way

Management is a Form of Human Behavior

- Rational (linking actions to desired outcomes), one would hope
- Management models must let us test alternative human behaviors
 - Different operating policies
 - Building and operating new things
 - Changing values
 - Leaving things alone

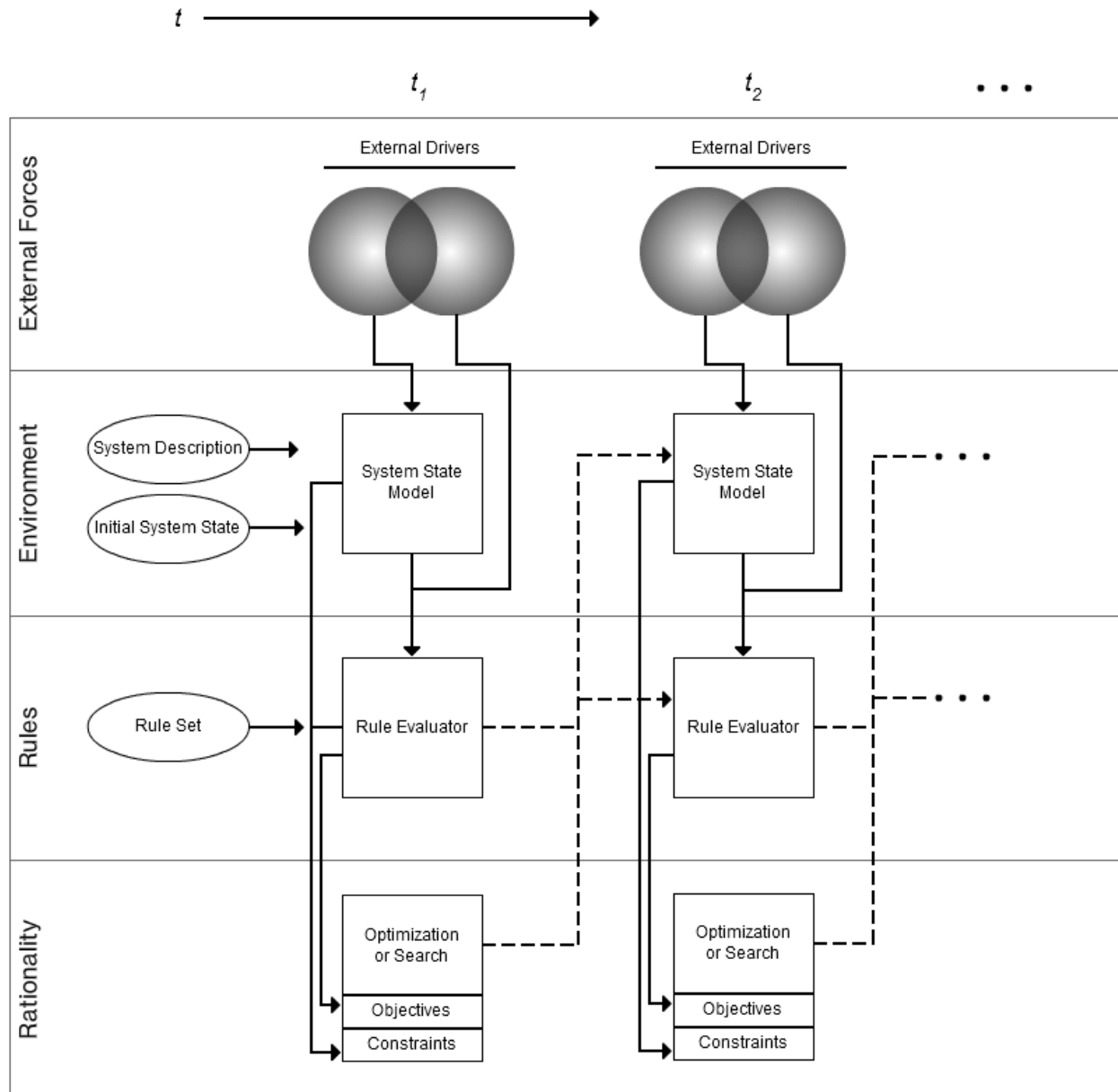
A “Model” of Human Behavior

- Short-term objectives and constraints
 - Determined by current factors
- Rules set short-term objectives and constraints
- Rules evolve (or are designed) to obtain long-term objectives
- Actions affect the environment which then determines current factors.....

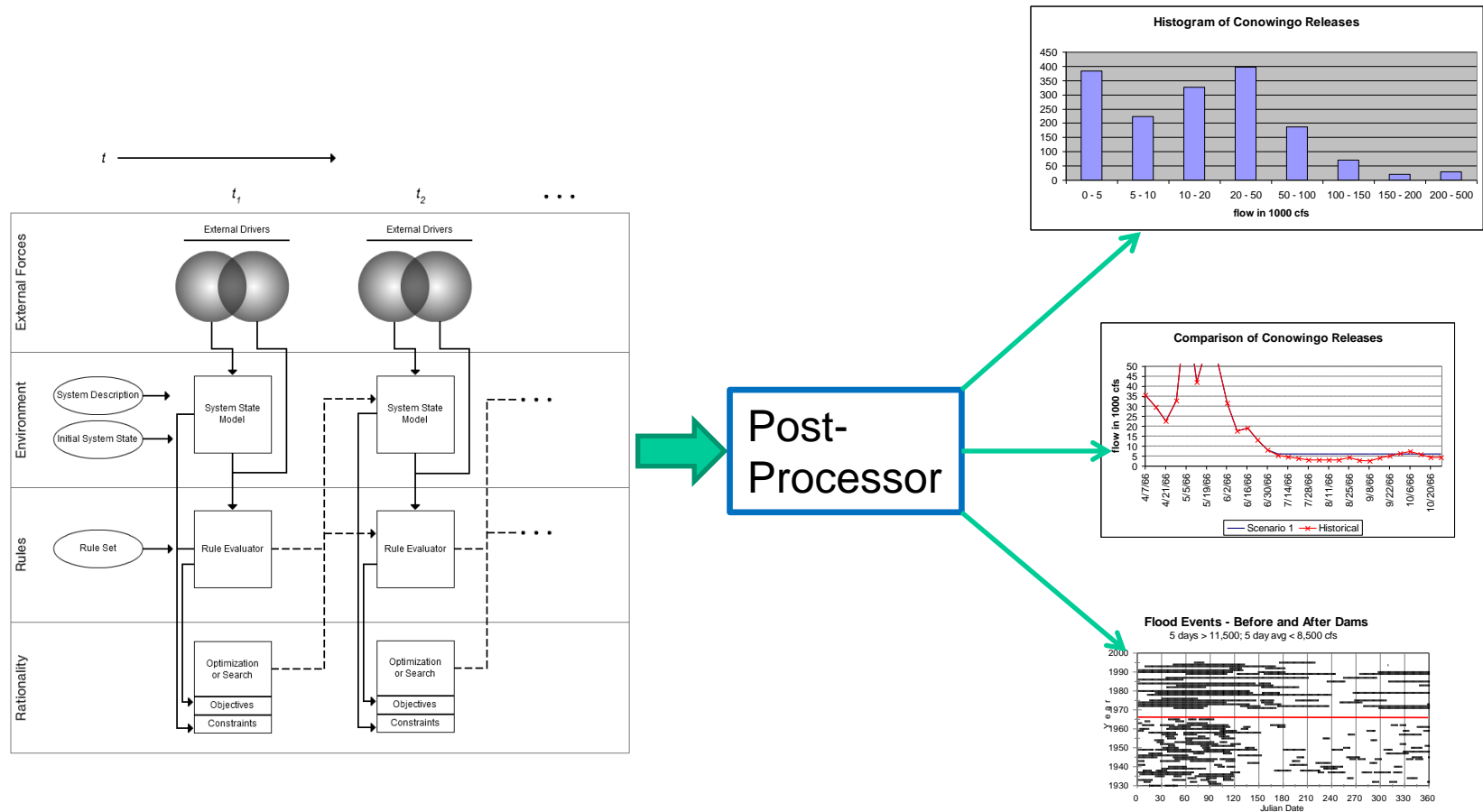
A Management Model Has

- Time series of external data that “drive” the model (boundary conditions)
- Science that links the drivers and human responses to determine what happens (system state)
- Rules that dictate human reactions, including short-term optimization

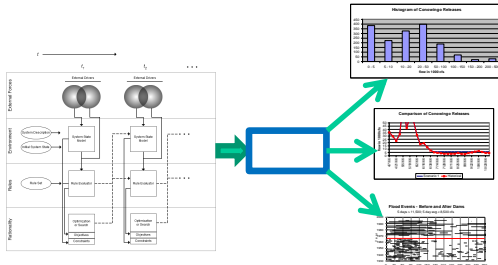
Generalized Management Model Schematic



Post-Processors Convert Model Output to PMs Based on Science

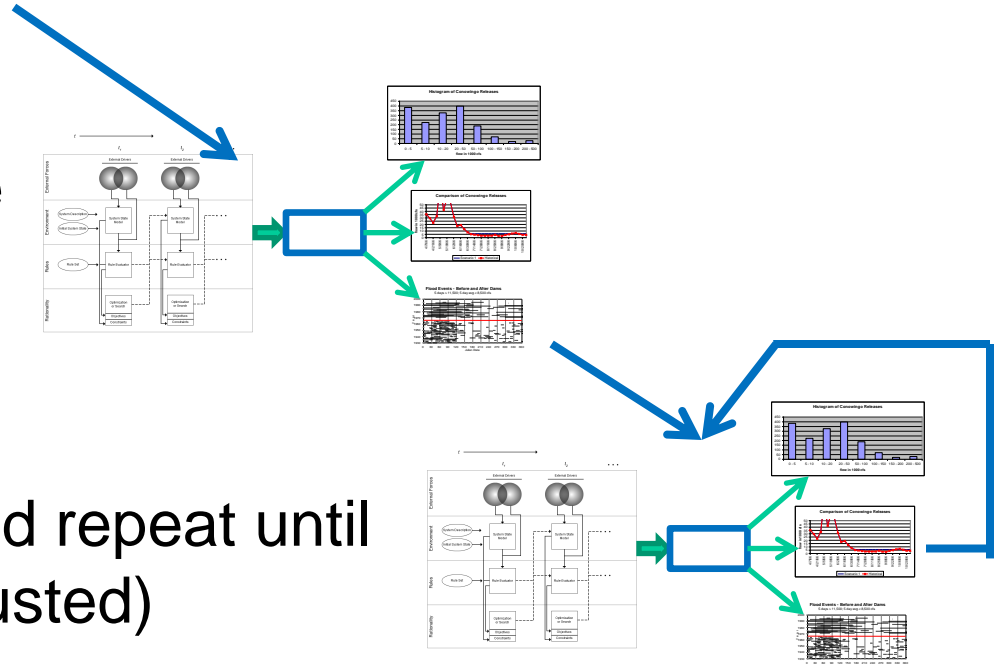


Using Management Models



1. Evaluate natural/current base case(s)

2. Evaluate alternative that improves PMs



3. Lather, rinse and repeat until satisfied (or exhausted)

What's Possible Changes Values

- When iterating to find better solutions, perceptions of what tradeoffs are desirable will change
- Prior economic “willingness to pay” may no longer be appropriate
- Modeler’s cannot know how values will change
- Stakeholder involvement is critical

Rule Inputs

- Rules have both forms and parameters
- Rules can be static or dynamic
 - FITFIR
 - Reservoir Rule Curves
 - Minimum Flows
 - Conservation practices
 - Habitat creation
 - Objectives and constraints for optimization

New Rule Forms are Important

- Imagination is limited by tools
- Models should accommodate the widest reasonable range of rule forms
- Dynamic rules depend on system state and external drivers
- Optimization rules require an optimizer
- Some sort of scripting language is needed to change the forms of rules

Management Model Output (PMs)

- Surrogates for short- and long-term objectives
- Most management PMs long-term, but not all
- Most benefits from water resources are local, so PMs for water resources are unique to locale

Human Behavior Targets Values (Performance Measures)

- PM design is the most intellectually demanding part of the modeling process
- Management Models must produce PMs
- Managers generally try to achieve short term PMs as surrogates for improving long term performance

What Is A Performance Measure?

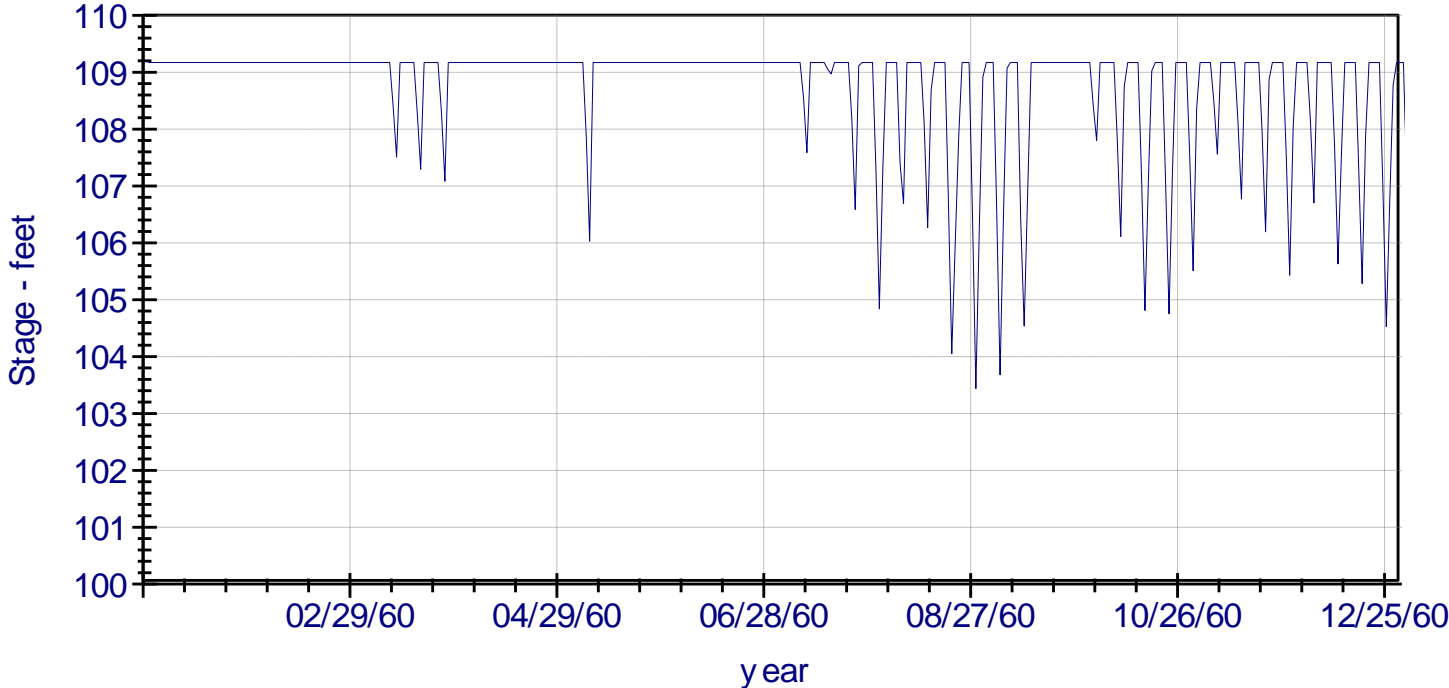
- A display
- Compares alternatives for one management objective
- Needs only to distinguish "better" and "worse"
- Water management is multi-objective
- Multiple performance measures are required

Performance Measures Must Be:

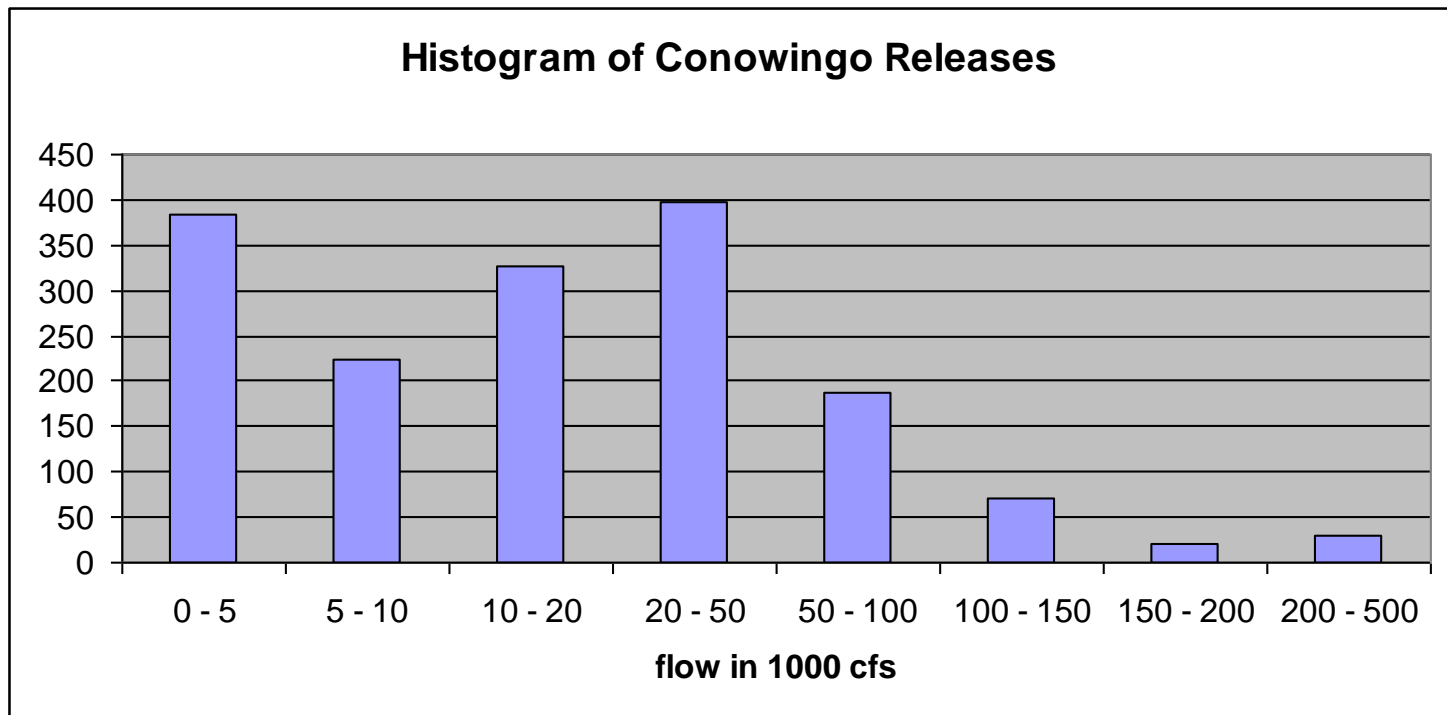
- Meaningful and Understandable
- Credible
- Reproducible

Performance Measures

Conowingo Stage

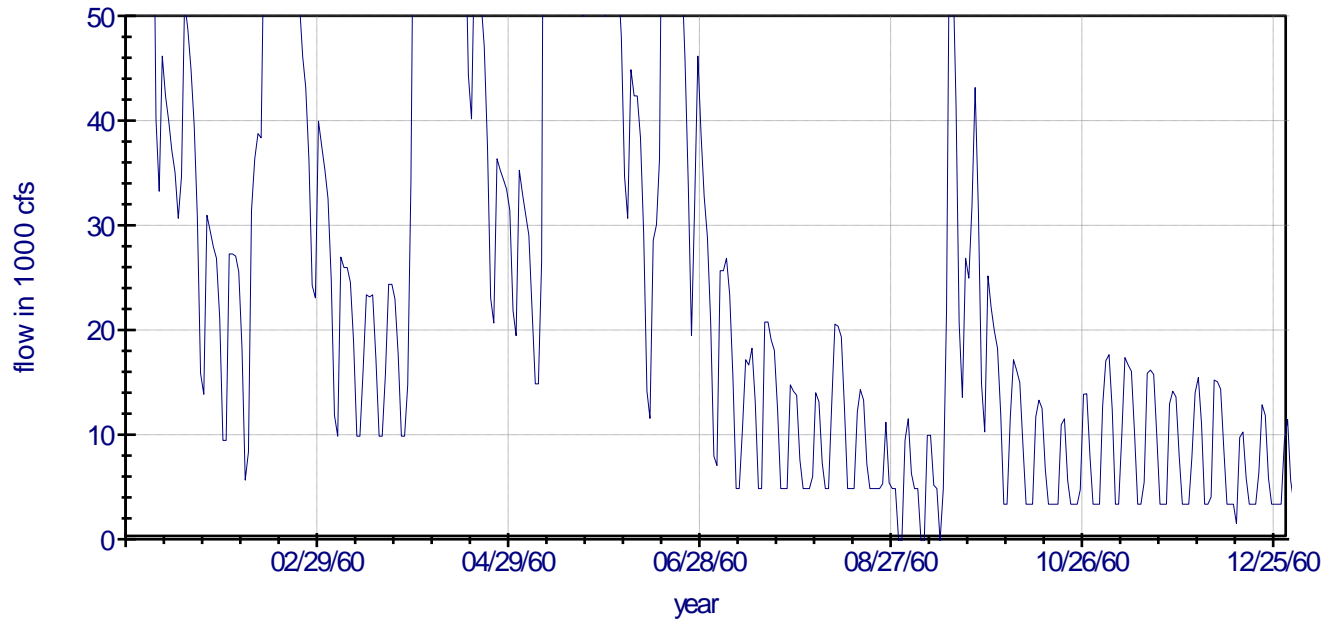


Performance Measures

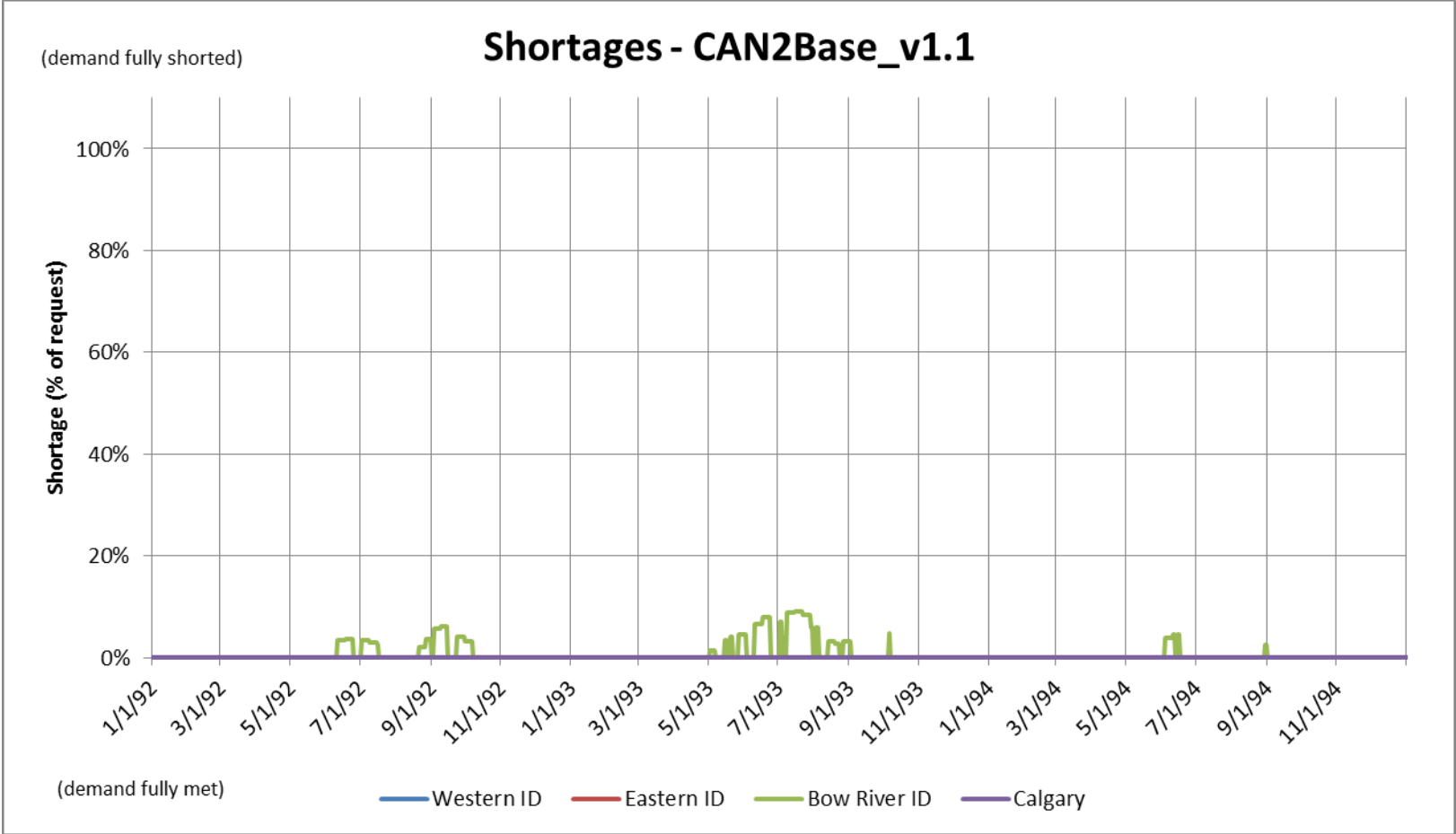


Performance Measures

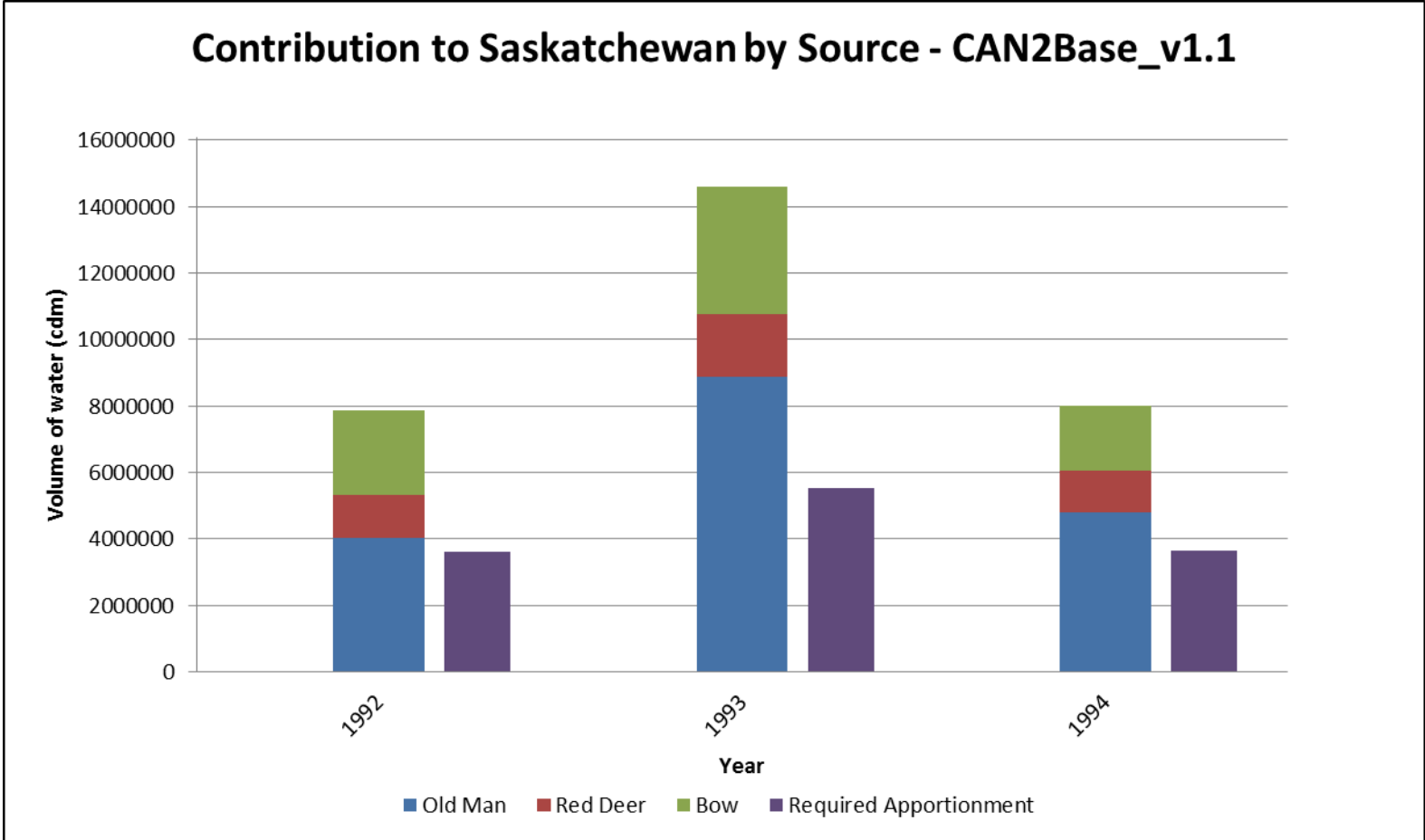
Conowingo Release



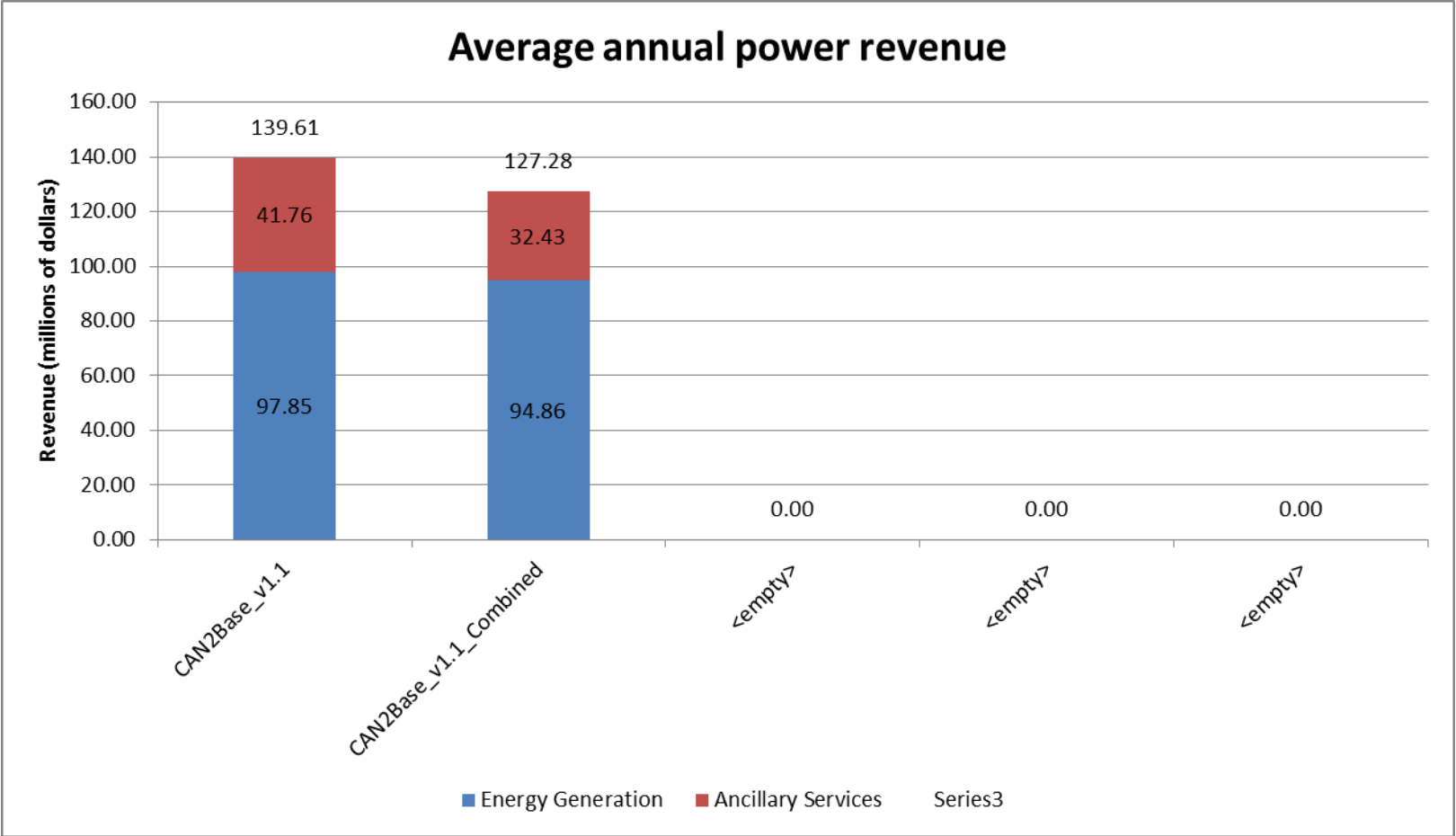
Performance Measures



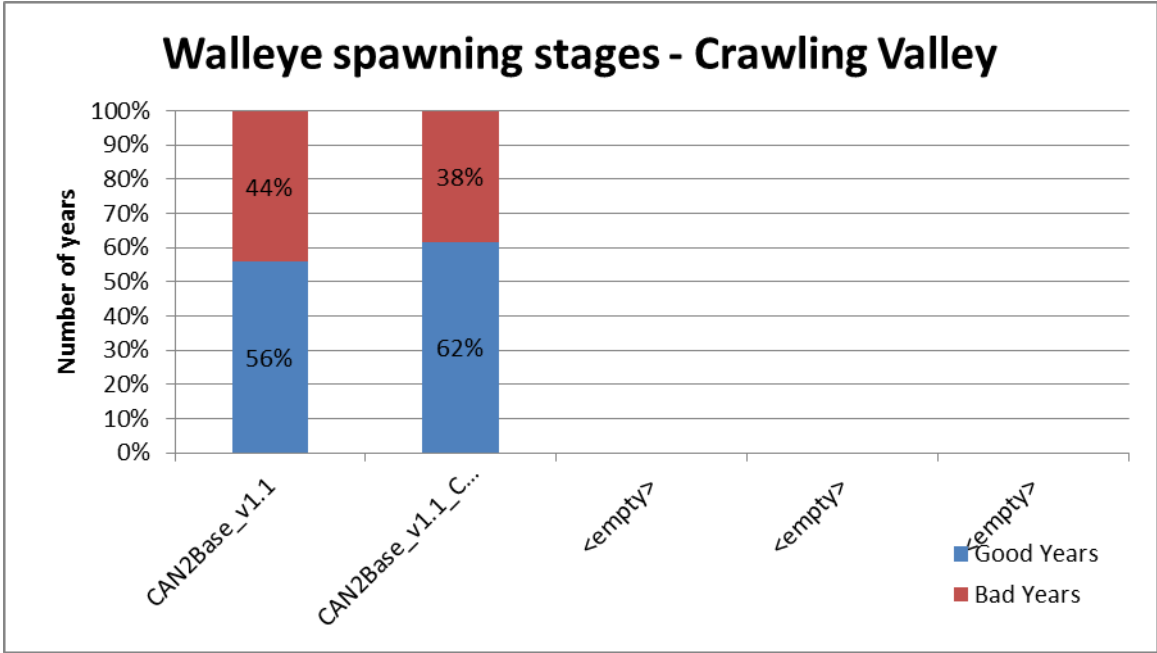
Performance Measures



Performance Measures

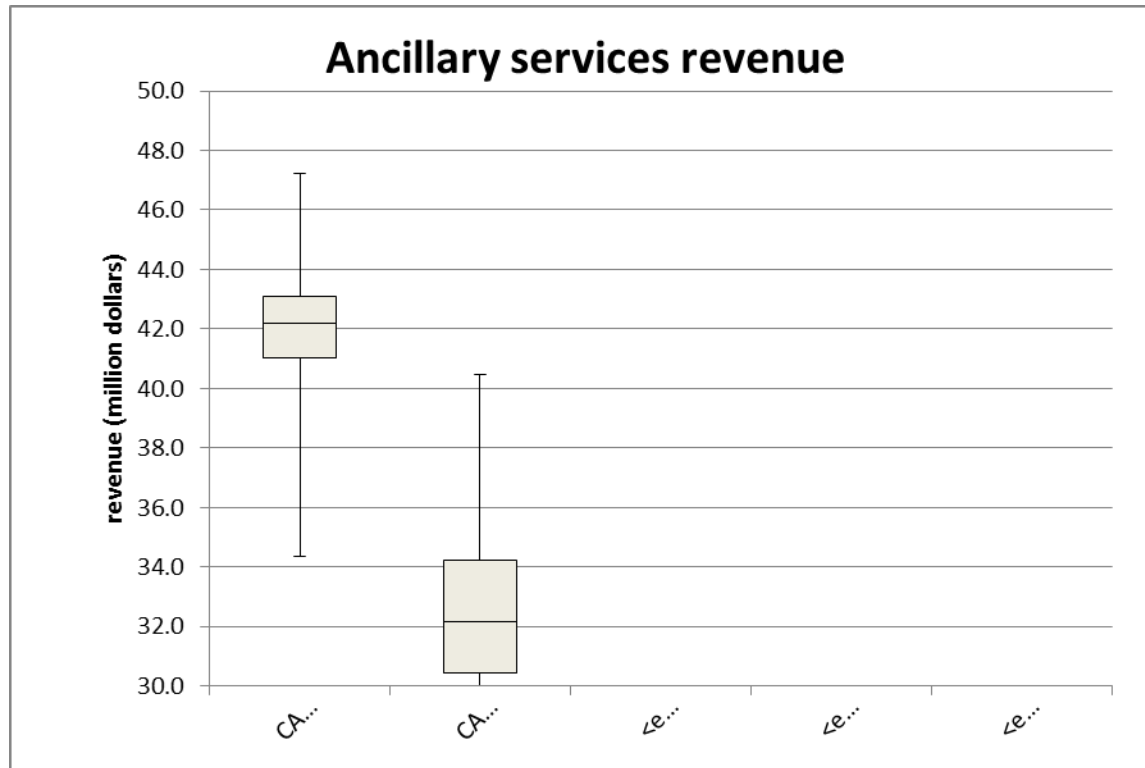


Performance Measures

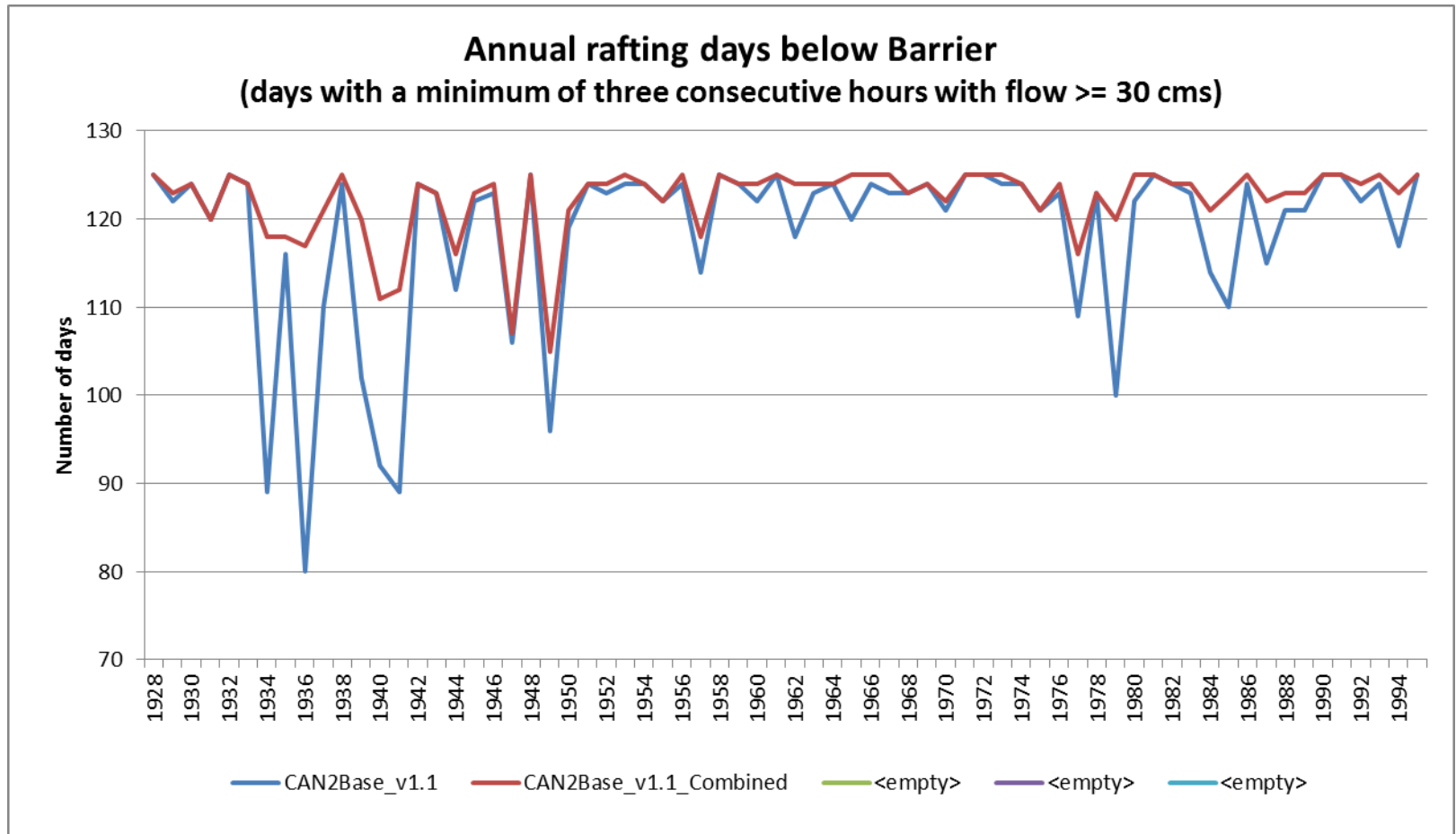


If the stage on June 1 is lower than that on April 1 then the walleye eggs have not been protected and the year is considered bad for walleye spawning. Pike spawning needs are similar to walleye.

Performance Measures



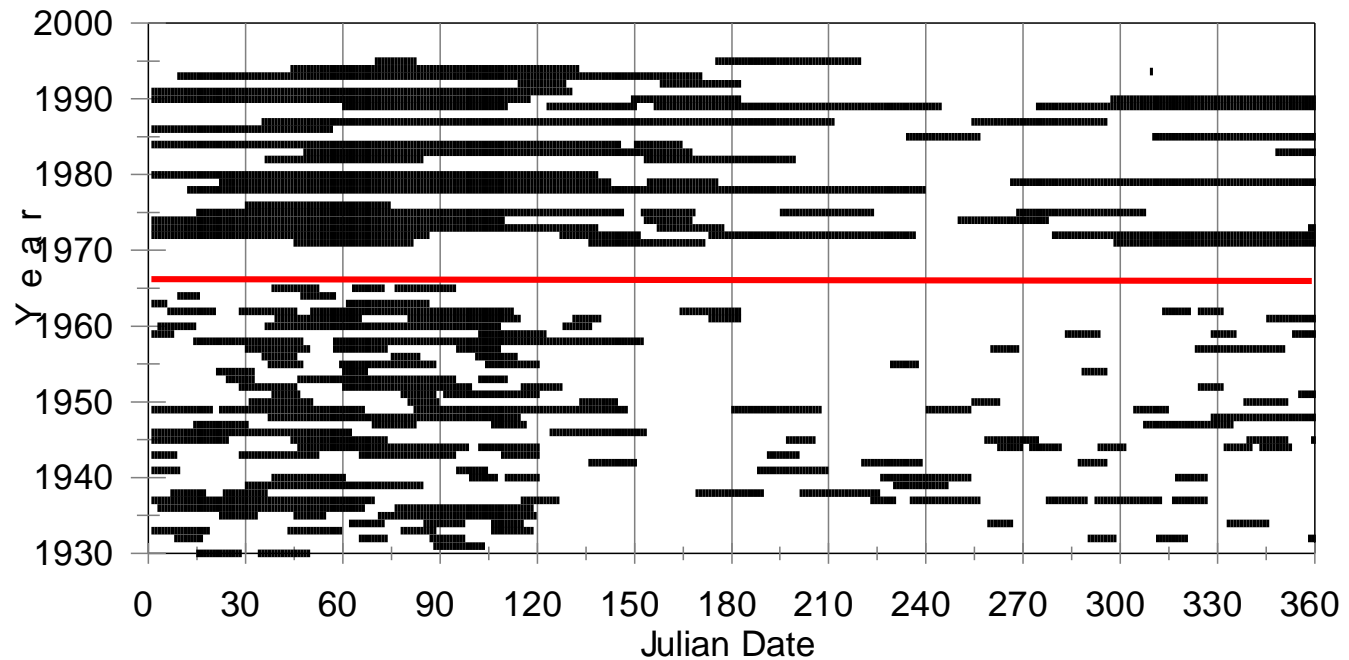
Performance Measures - Surrogates



Performance Measures - Surrogates

Flood Events - Before and After Dams

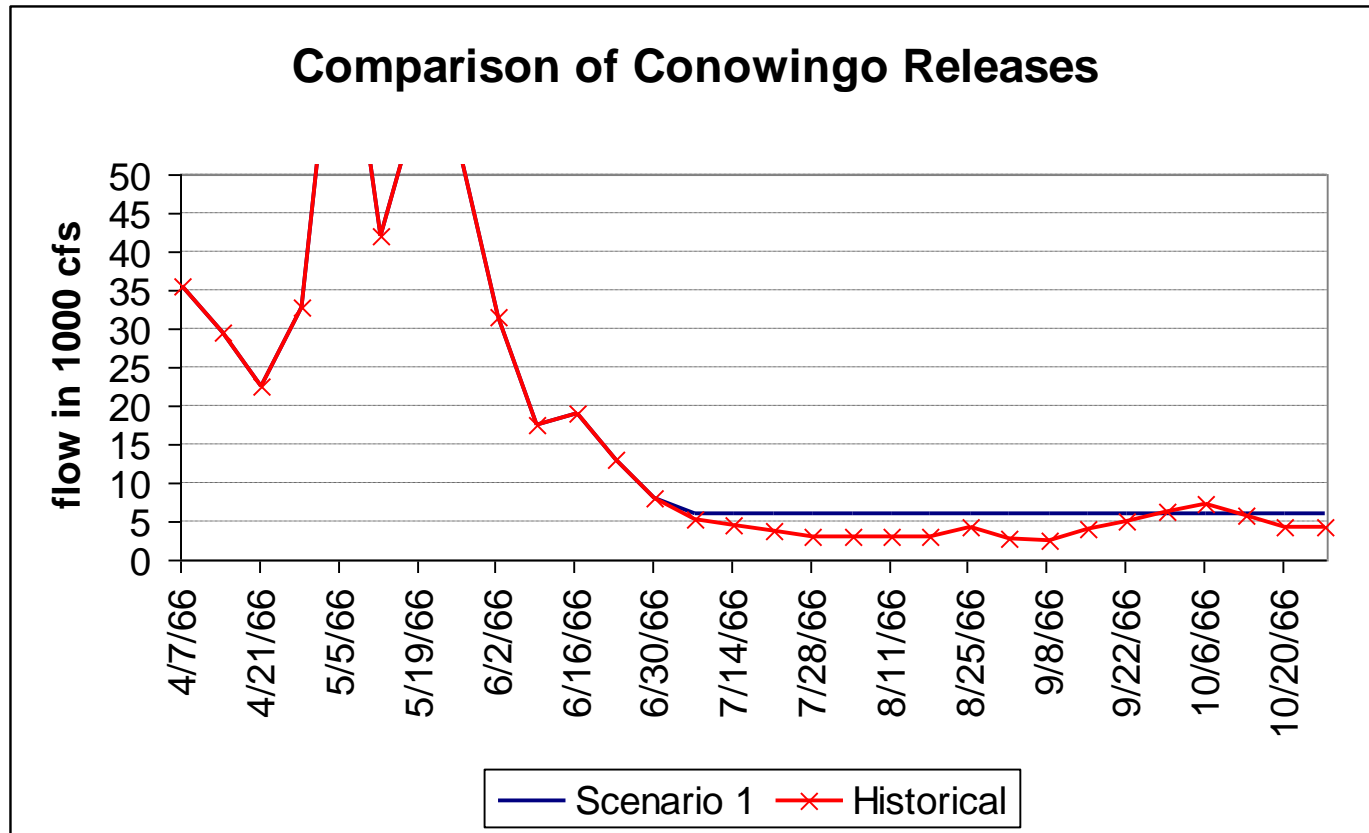
5 days > 11,500; 5 day avg < 8,500 cfs



Performance Measures

Scenario	Number of Days in Water Restriction	Number of Years with Water Restrictions	Volume of Water Not Delivered (million gallons)
1	10	1	25
2	16	3	30
3	5	5	5
4	25	3	140
5	30	6	130
6	18	2	65

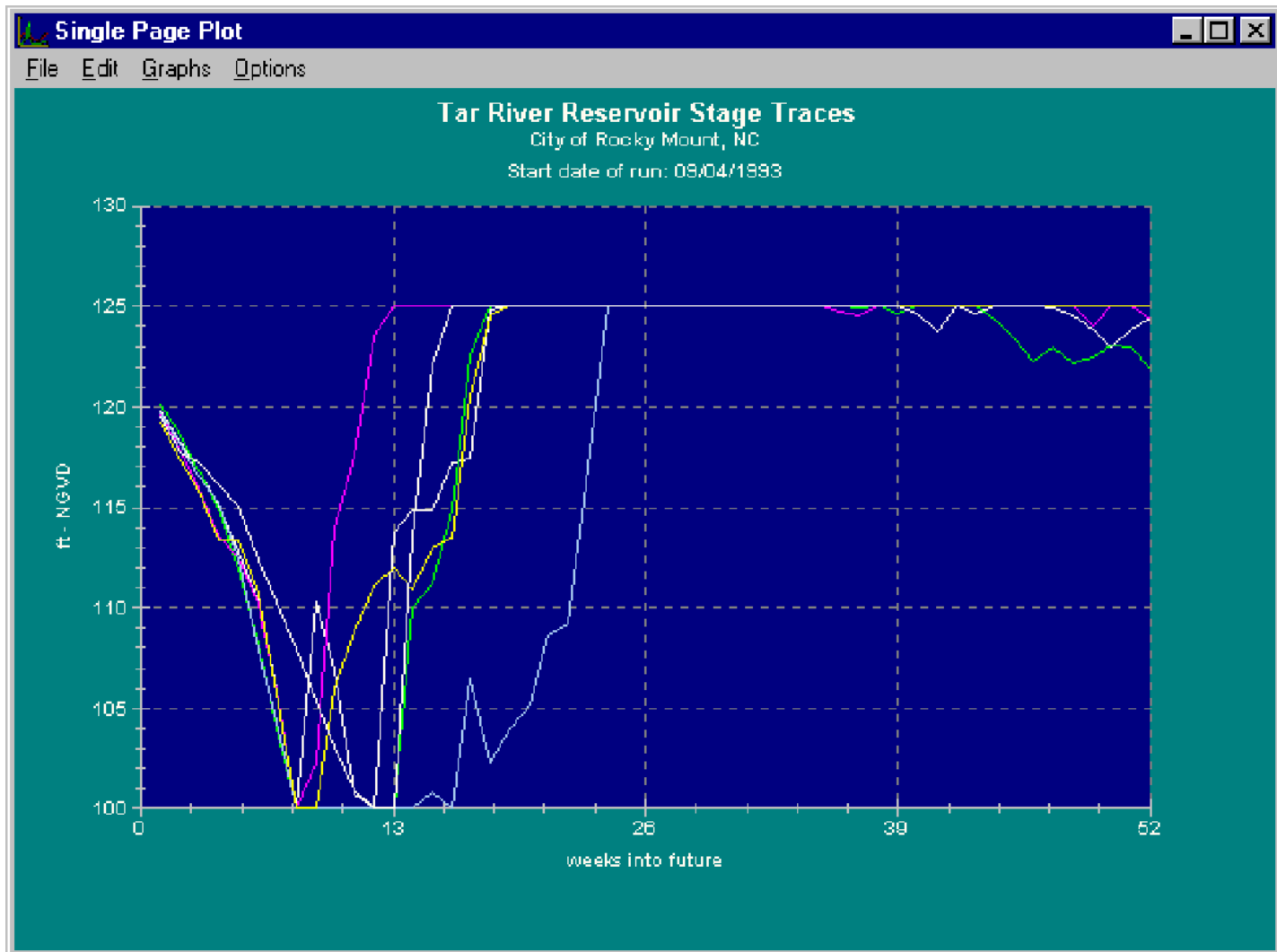
Performance Measures - Surrogates



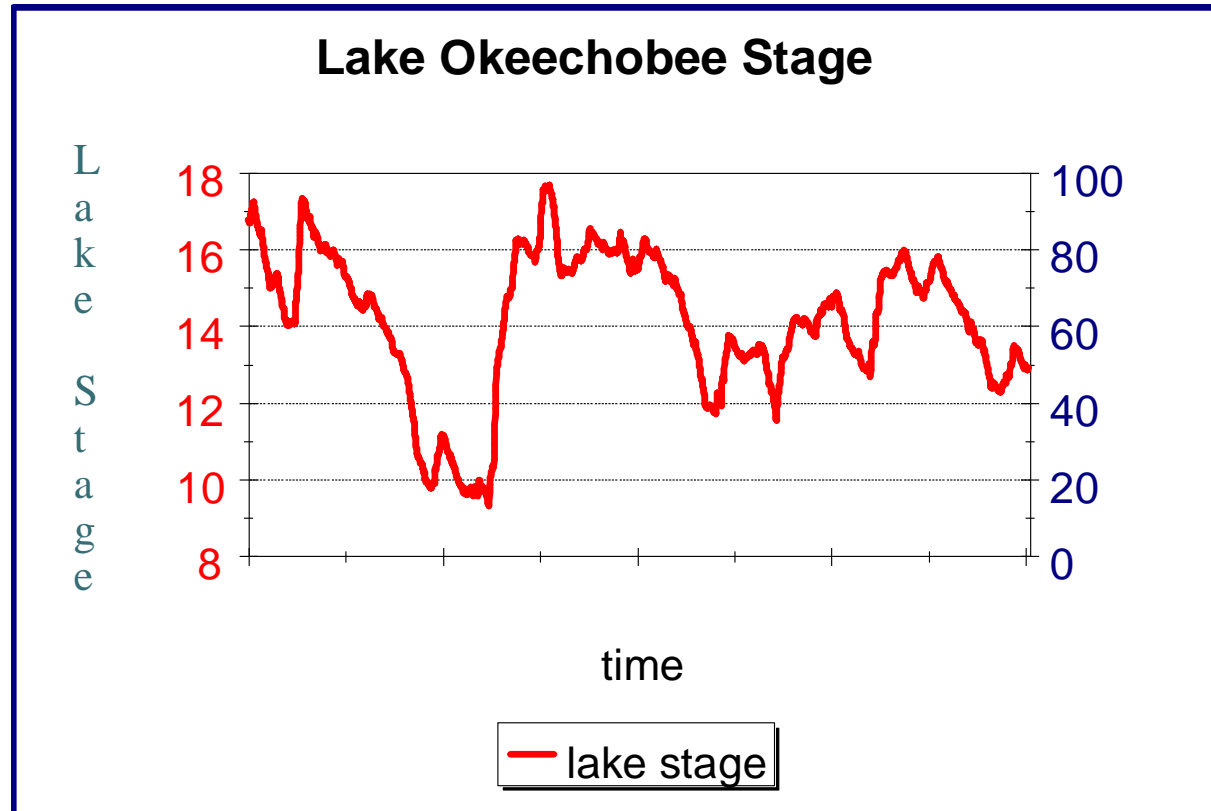
Planning and Operations Measures

- Planning Measures - Long term performance, statistics, historical "worst case," expected duration
- Operations Measures - Given "current conditions" - shorter term performance, statistical measures, conditional "worst case" and duration

Performance Measures - Operations



Process for Developing Performance Measures



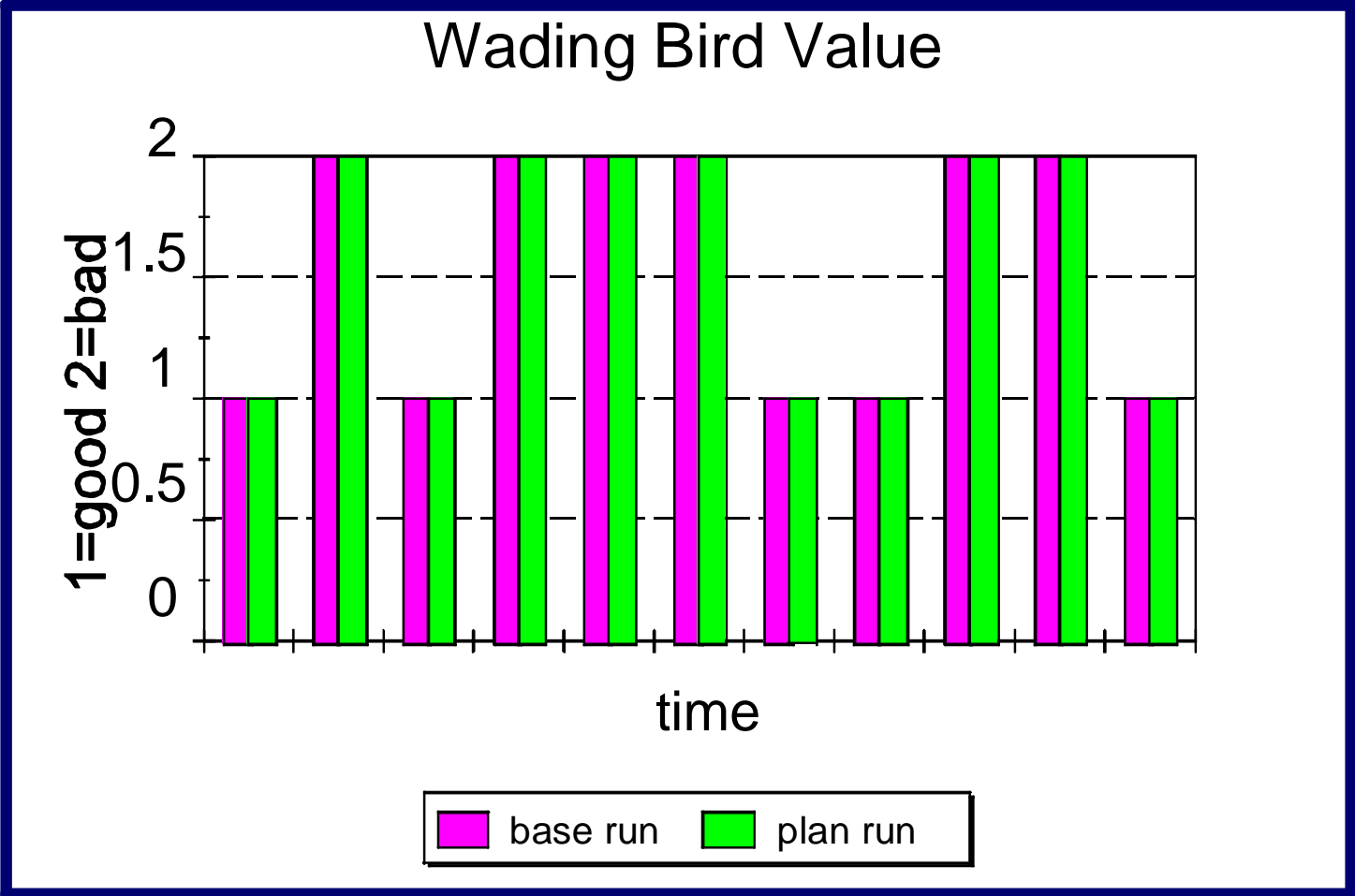
© 1997 Water Resources Management Inc.

Scientific Rationale

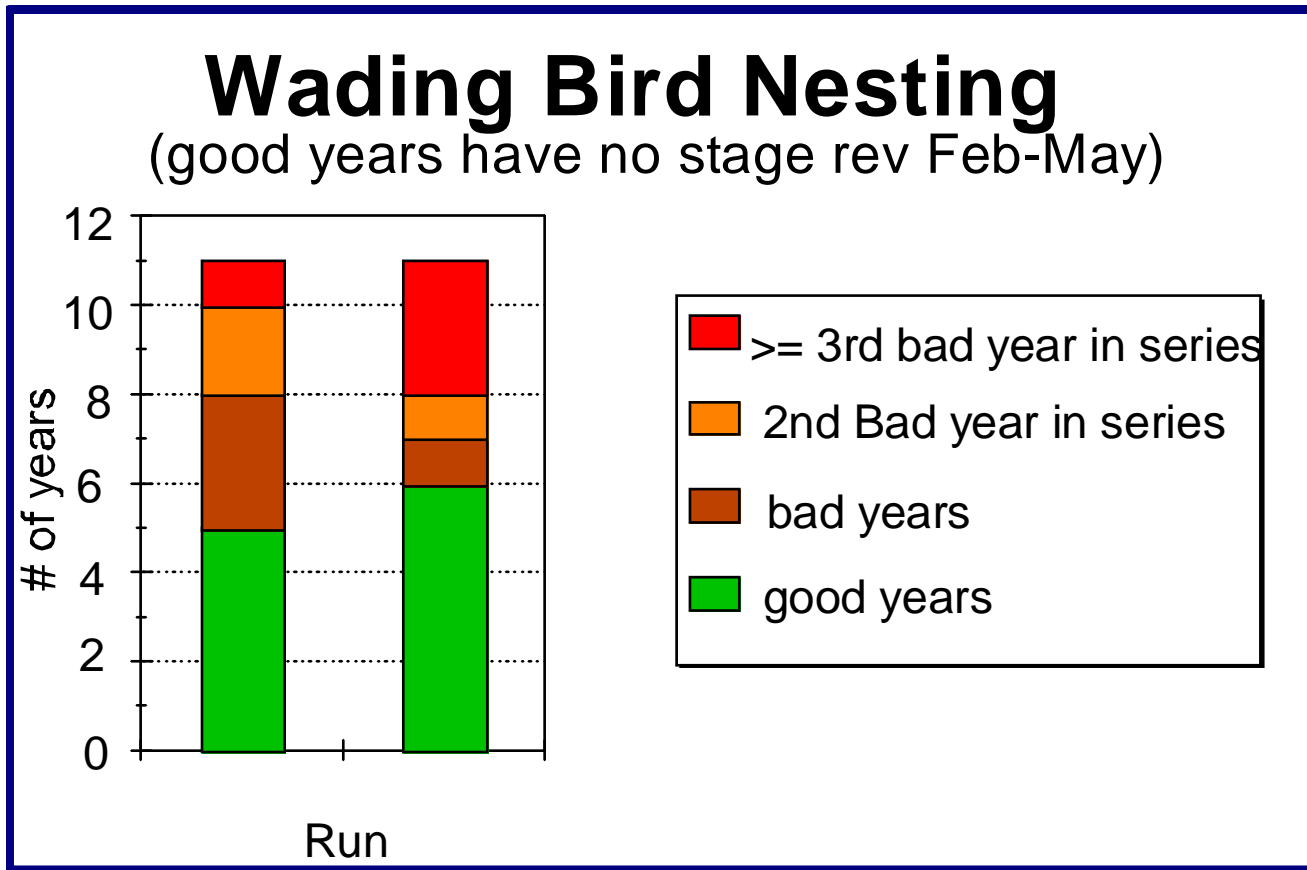
- No habitat if lake stage exceeds 15 feet
- No forage if lake stage reverses by more than 6 inches

Performance Measure

First Attempt



Performance Measure Revised



Model Care and Feeding

- Models must be updated to reflect new data, science, and values, to add functionality and to upgrade technology
- Scientific models get updated immediately
- Management models, particularly regulatory models update infrequently- provide a stable regulatory environment

Making Models Public

- Advantages
 - Reduced agency workload for permitting
 - Free model review
 - Better public understanding of requirements
 - Transparency
- Disadvantages
 - Maintenance
 - Transparency

Conclusions

- Management is about values
- Management uses rules
- Management models make it possible to use science to evaluate the performance of rules in terms of values
- Management models must be flexible in terms of rules
- Output must show results in terms of values (PMs)