

US EPA ARCHIVE DOCUMENT

“Nature always wears the colors of the spirit” —EMERSON



# Integrating Water Supply And Ecological Flow Requirements

U.S. EPA Collaborative Science and Technology  
Network for Sustainability Progress Review  
Meeting

December 5 & 6, 2006  
Washington, D.C.



# Integrating Water Supply And Ecological Flow Requirements

## Co-authors:

Richard M. Vogel, Stacey Archfield and Yongxuan Gao,  
Tufts University

Jack Sieber and Brian Joyce, Stockholm Environment  
Institute

Colin D. Apse, The Nature Conservancy

## Related Collaborations:

Connecticut Dept. of Env. Protection

EPA Region I

Paper submitted to Water Resources Research



# The Nature Conservancy's mission:

To preserve the plants,  
animals and natural  
communities that represent  
the diversity of life on Earth by  
protecting the lands and



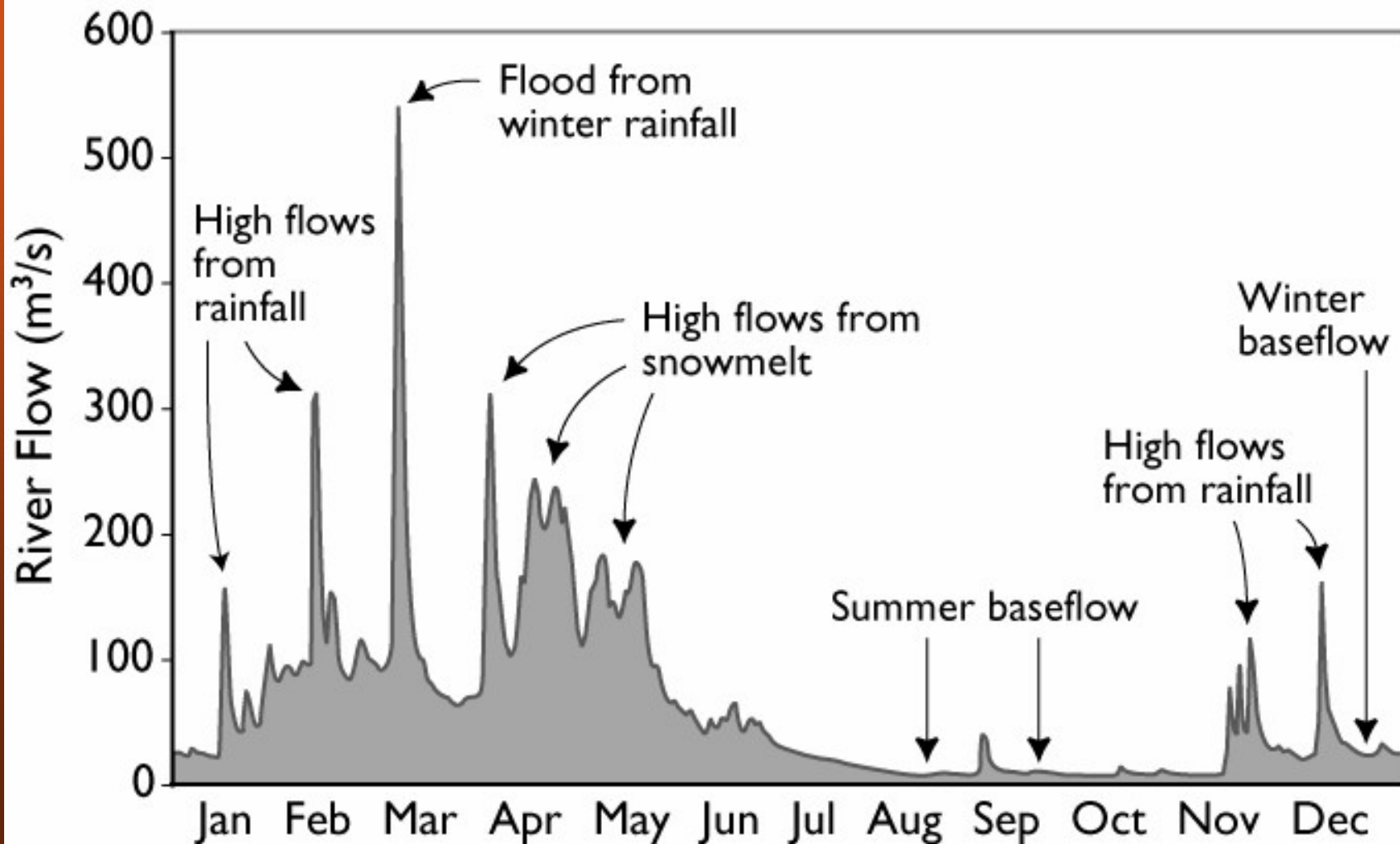


# Contribution to Sustainability

- ❖ Quantify trade-offs between competing water management objectives;
- ❖ Integrate a more precise definition of ecosystem flow needs into water supply management;
- ❖ Provide a tool for optimizing timing and use of drought management and water conservation techniques;
- ❖ Promote consensus-based decision-making to management of water resources.

# Natural Variability

## Inter and Intra Annual Variations

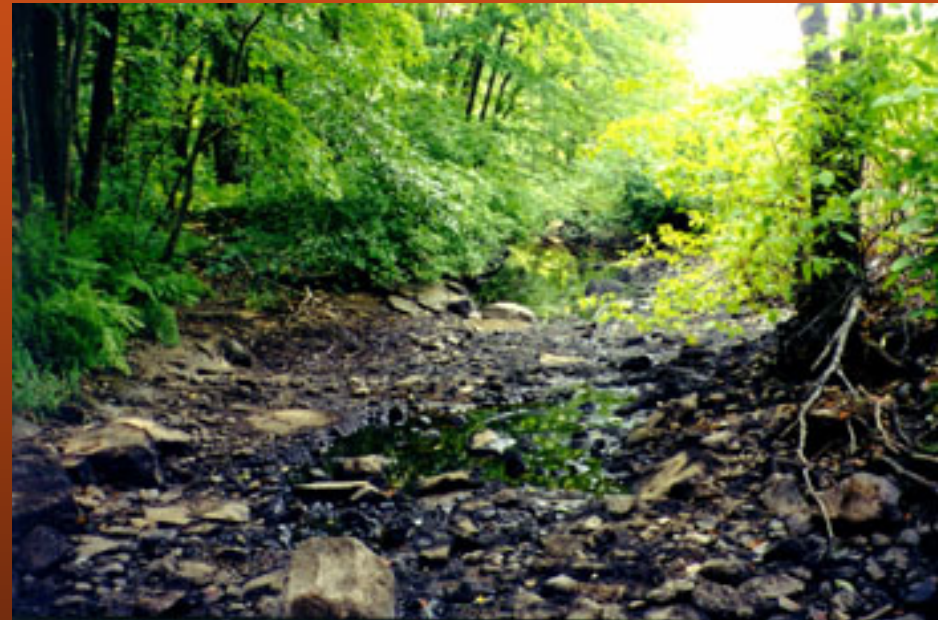


# Project Context

## Low Flow Conditions Massachusetts



Fish Brook, Boxford



Sudbury River, Hopkinton



# Project Context

Natural variations in  
precipitation can result in  
problems for water  
supplies



Middleton Pond,  
Massachusetts

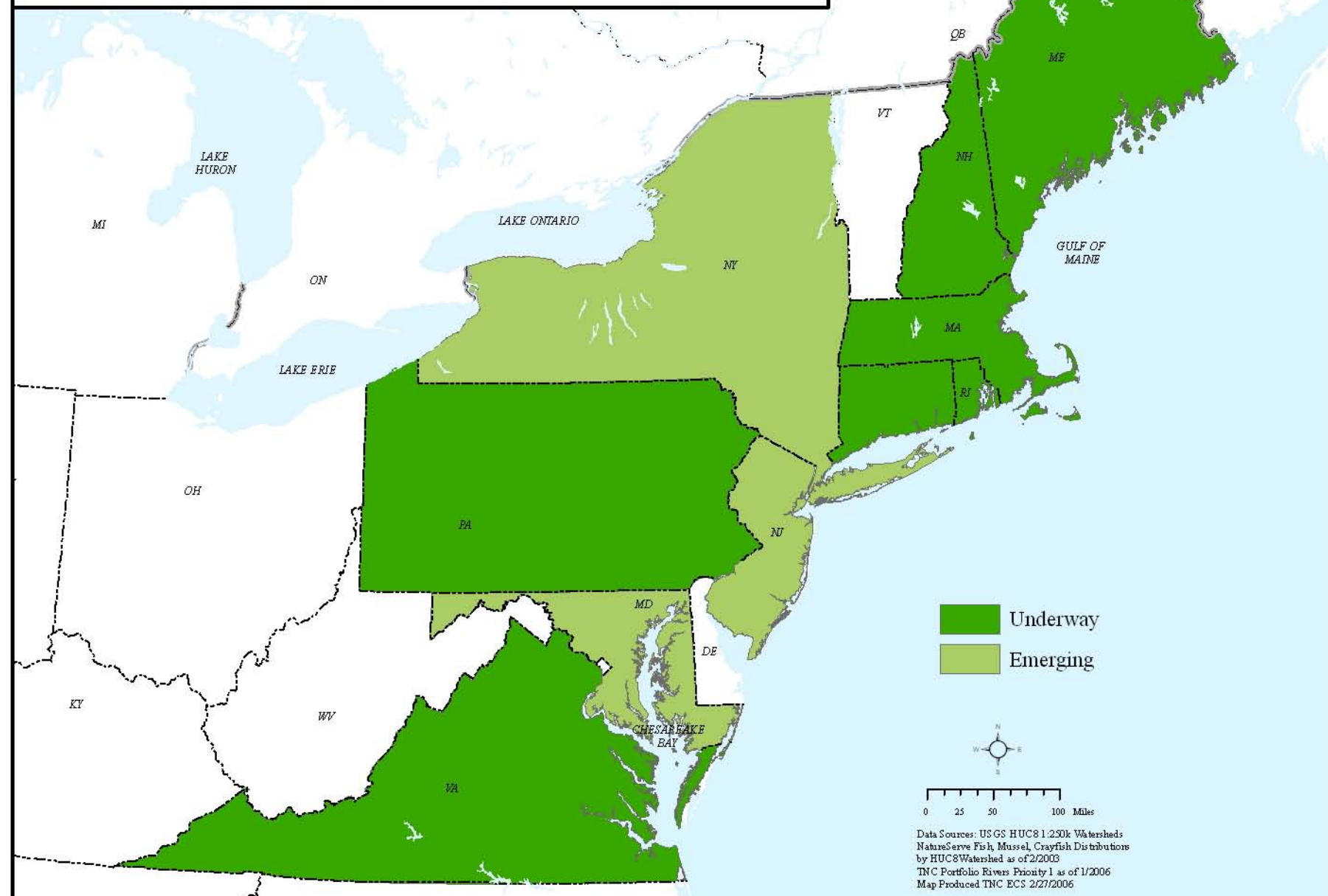


Wenham Lake  
Massachusetts



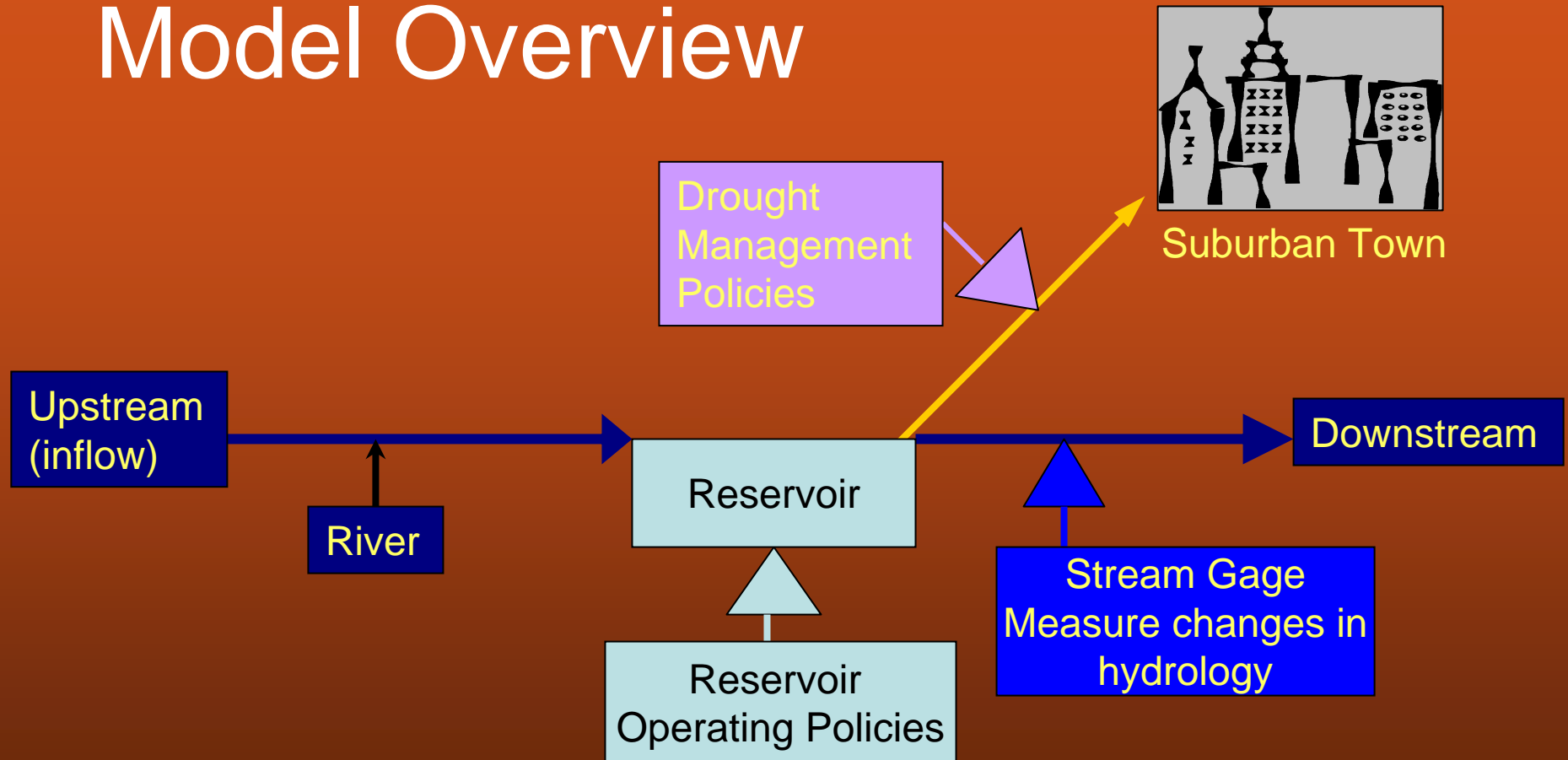
# States Working on Instream Flow Policy

DRAFT OF 10/1/2006





# Model Overview





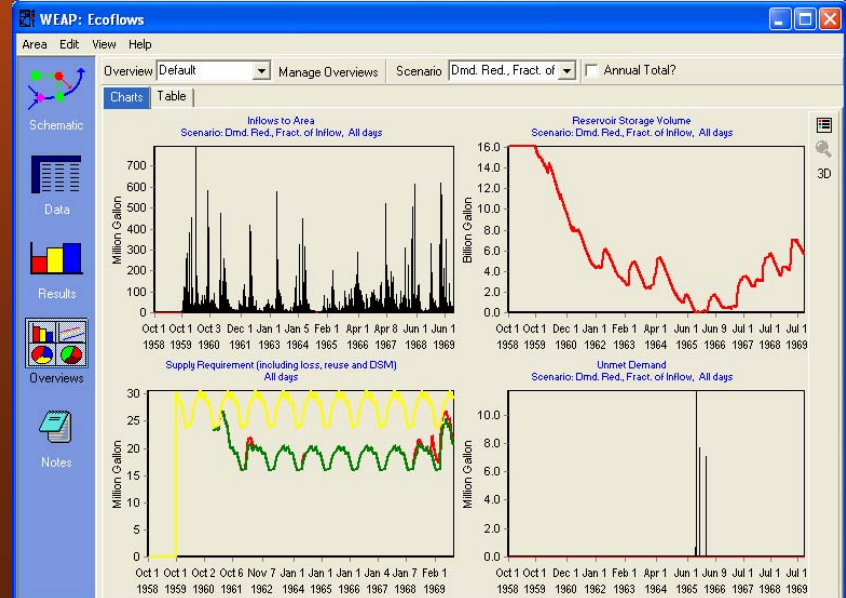
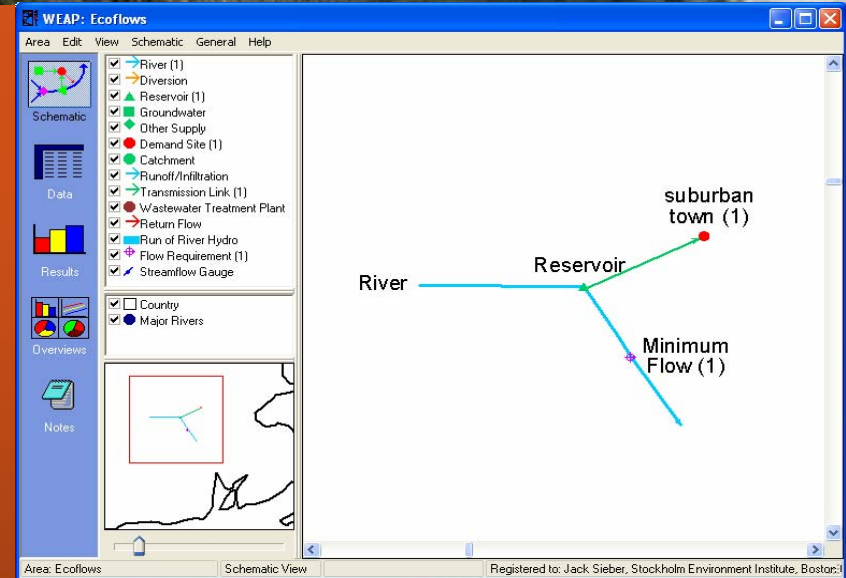
# Some initial lessons learned

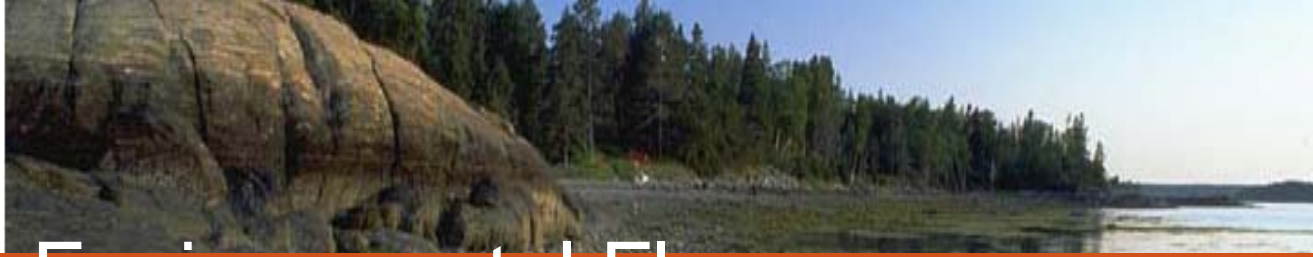
- ❖ Demand management increases reservoir yield;
- ❖ There are many different release policies that result in the same reservoir yield;
- ❖ Release requirements that are beneficial with small reservoirs may not be for large reservoirs;
- ❖ Reservoirs yield measures are well known



## Water Evaluation and Planning model (WEAP)

Developed by  
Stockholm  
Environment Institute





# Incorporating Environmental Flow Requirements into Water Supply Management

## Flow Policies:

1. Fixed minimum
2. Fraction of inflow
3. Adaptive based on reservoir levels
4. Flow components
  - add back some high flows

## Demand Policies:

1. Demand management
  - a) Reduce peak demands
  - b) Reduce all demands



# Measures

## Flow:

Eco-deficit

Statistical software:

IHA

USGS HIP statistics

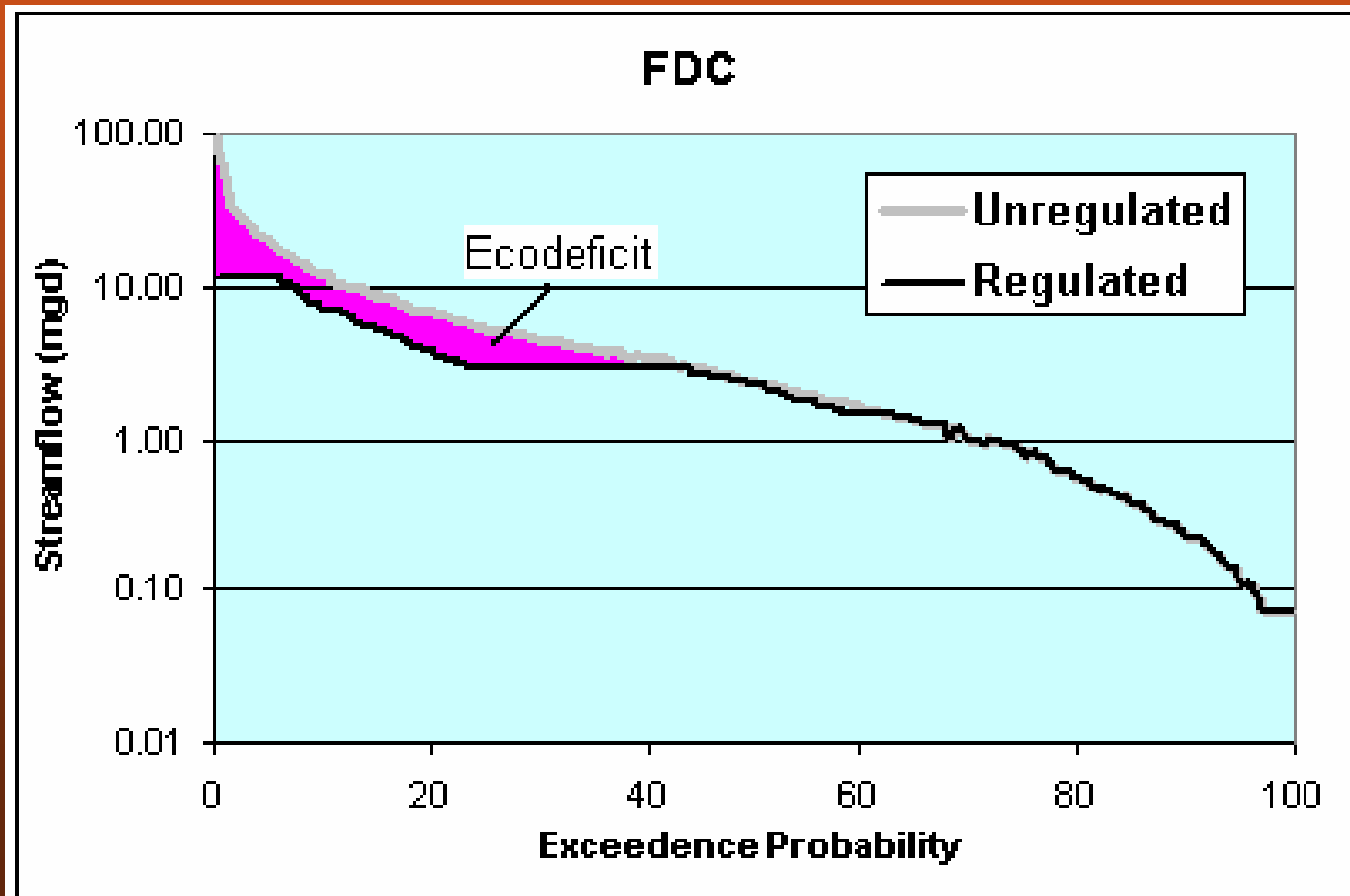
## Water Supply:

- Yield
- Reliability
- Resilience
- Reservoir Size
  - Storage Fractions  
1.0 and 0.1





# Measuring the 'Ecodeficit'

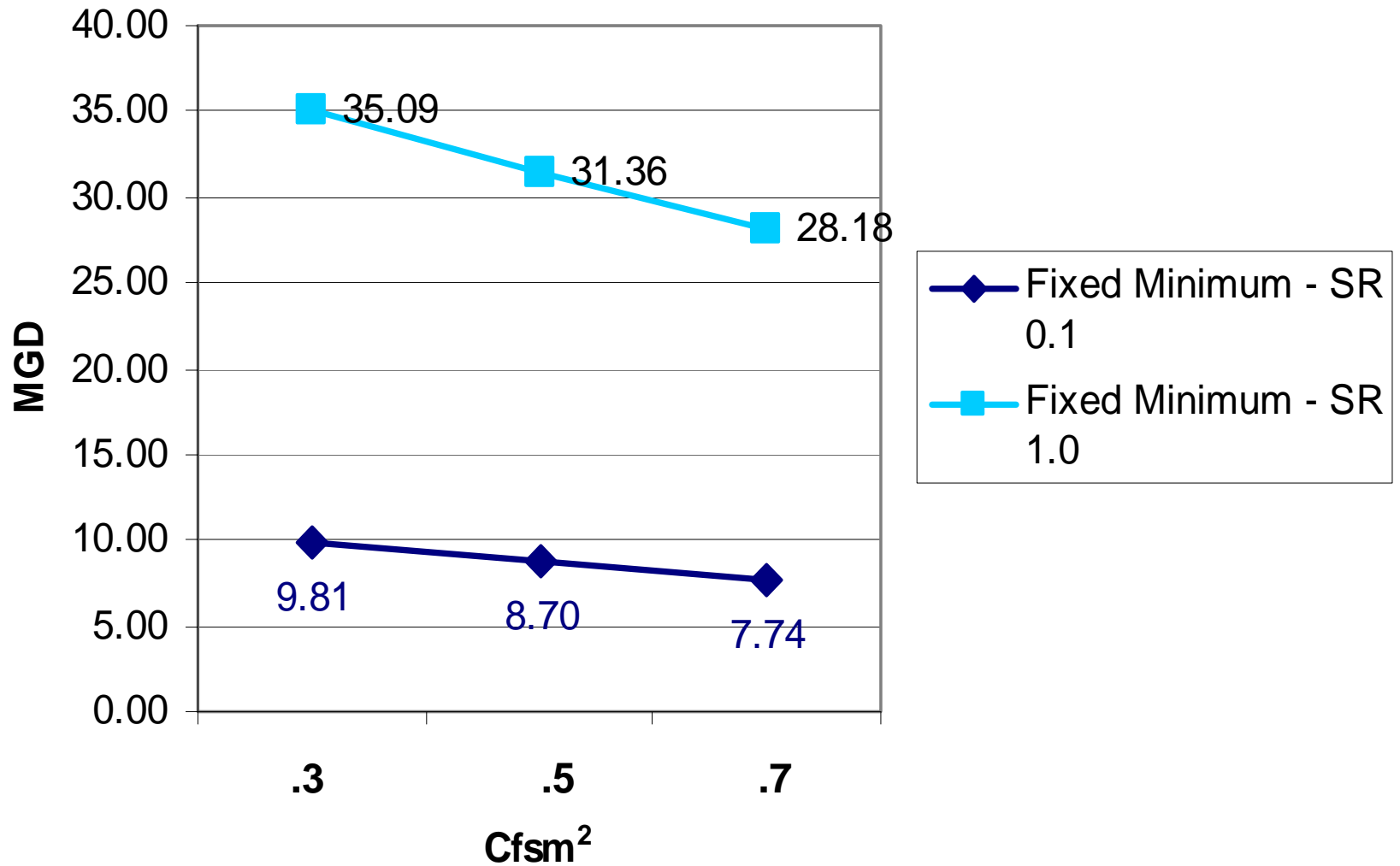




# Quantifying Trade-offs and Key Variables

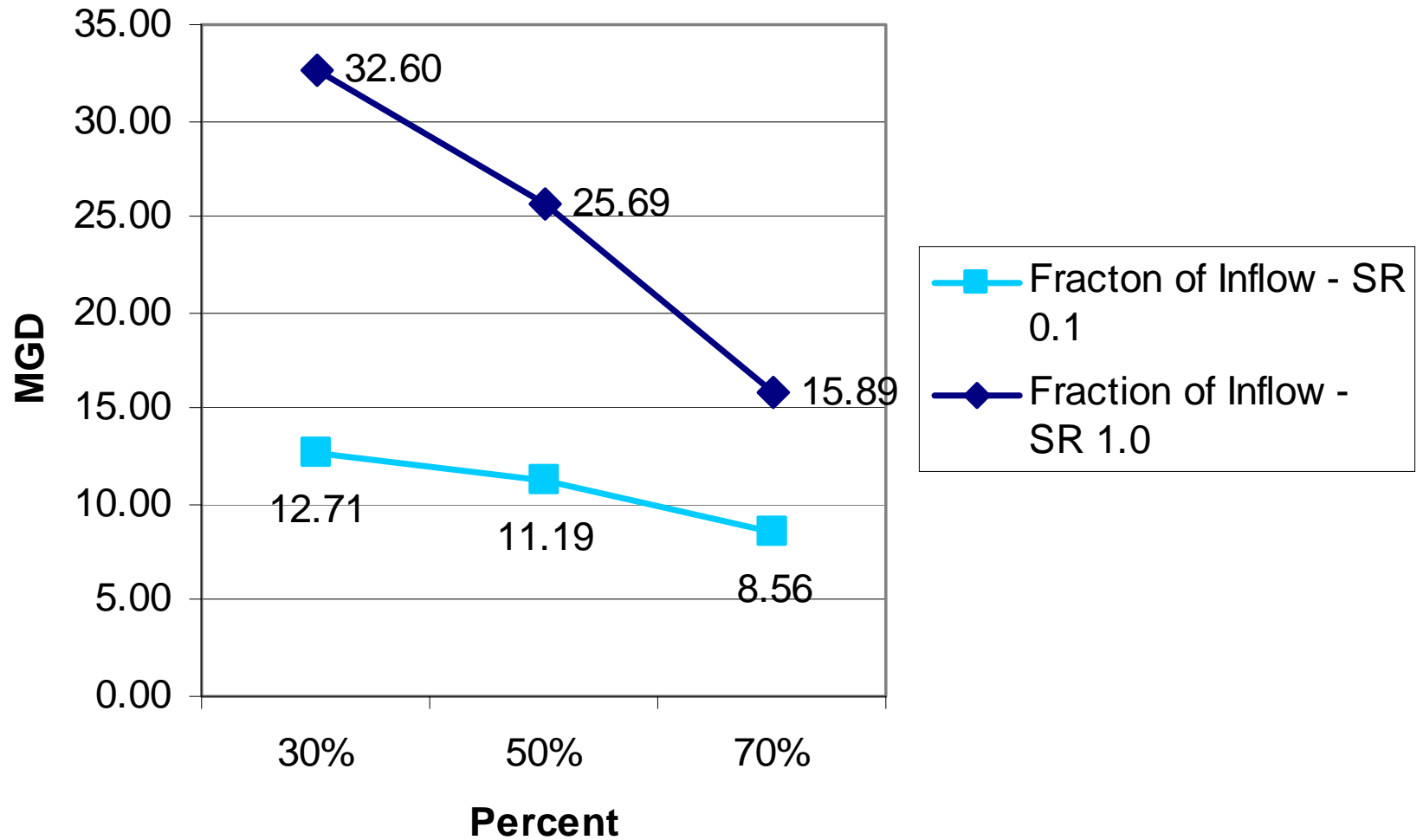
1. The relationship between water supply yield and flow requirements;
2. Small reservoirs behave differently than large reservoirs;
3. Same yield can result in different flows;
4. Measuring trade-offs between policy objectives
5. Drought management increases overall

## Yield response to flow requirement

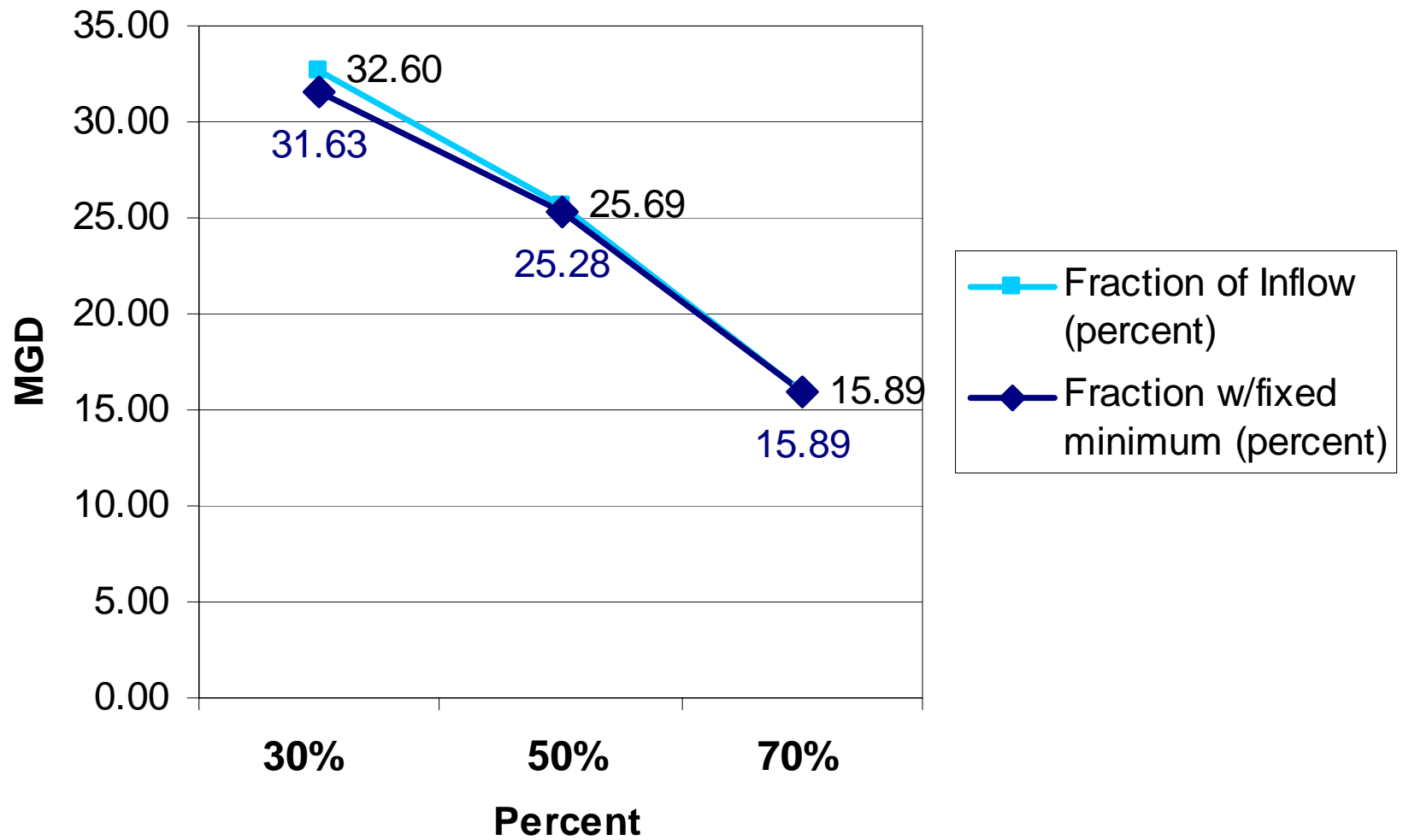




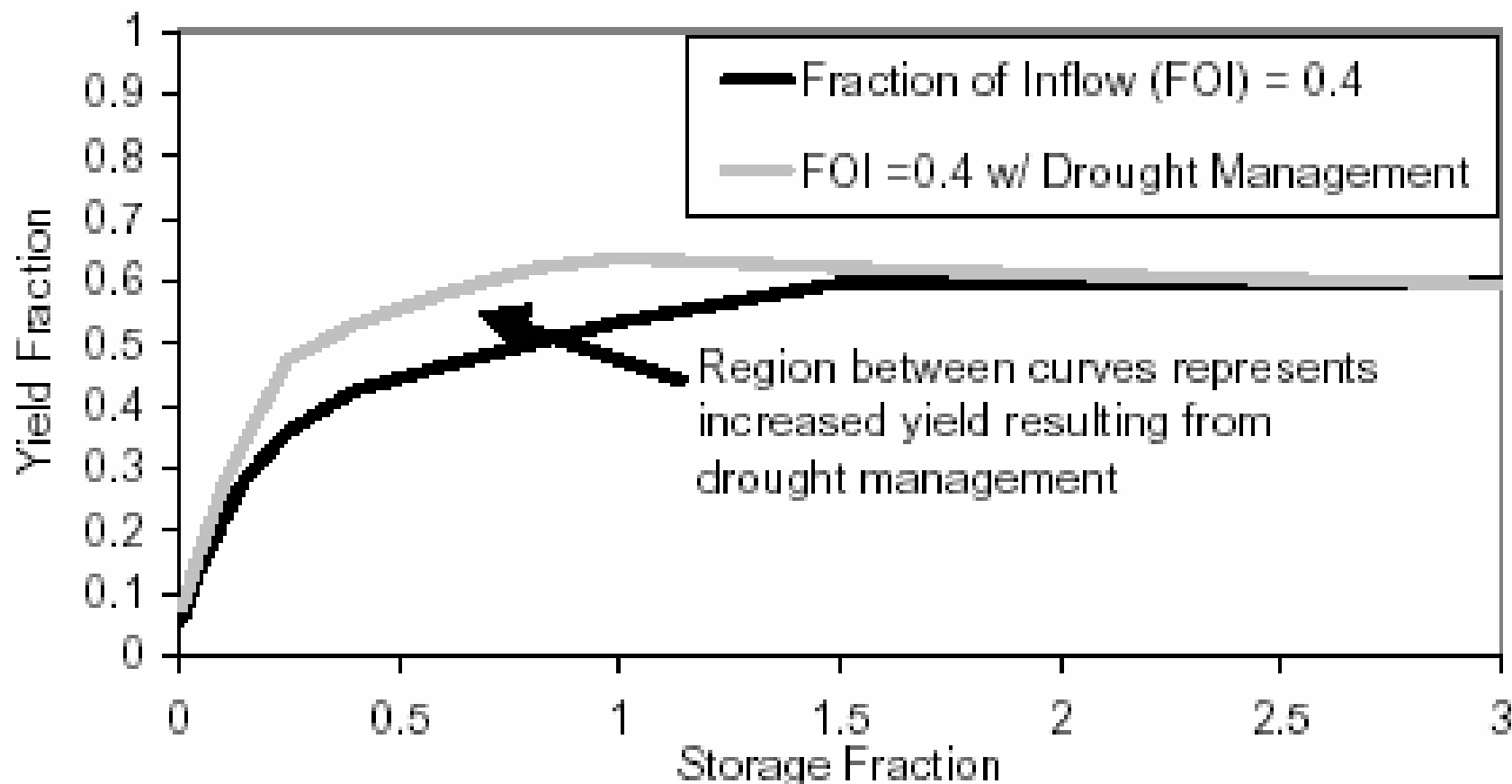
## Yield response to flow requirement



## Yield response to flow requirement



## Demand Management Increases the Yield of Water Supplies







# Quantifying Trade-offs and Key Variables

1. The relationship between water supply yield and flow requirements;
2. Small reservoirs behave differently than large reservoirs;
3. Same yield can result in different flows;
4. Measuring trade-offs between policy objectives
5. Drought management increases overall

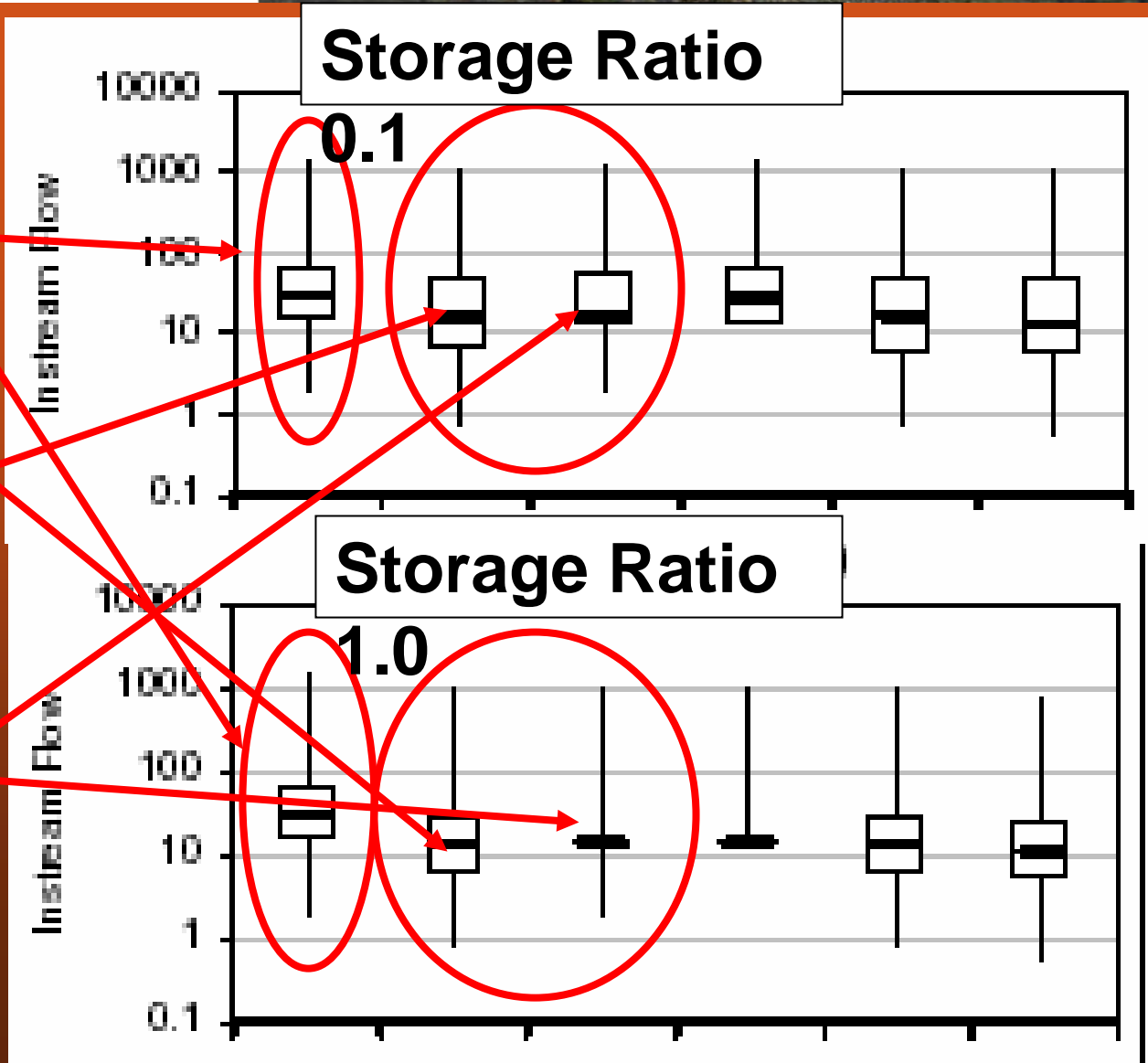
# Reservoir Size



**Inflow**

**Fraction**

**Fixed Min.**



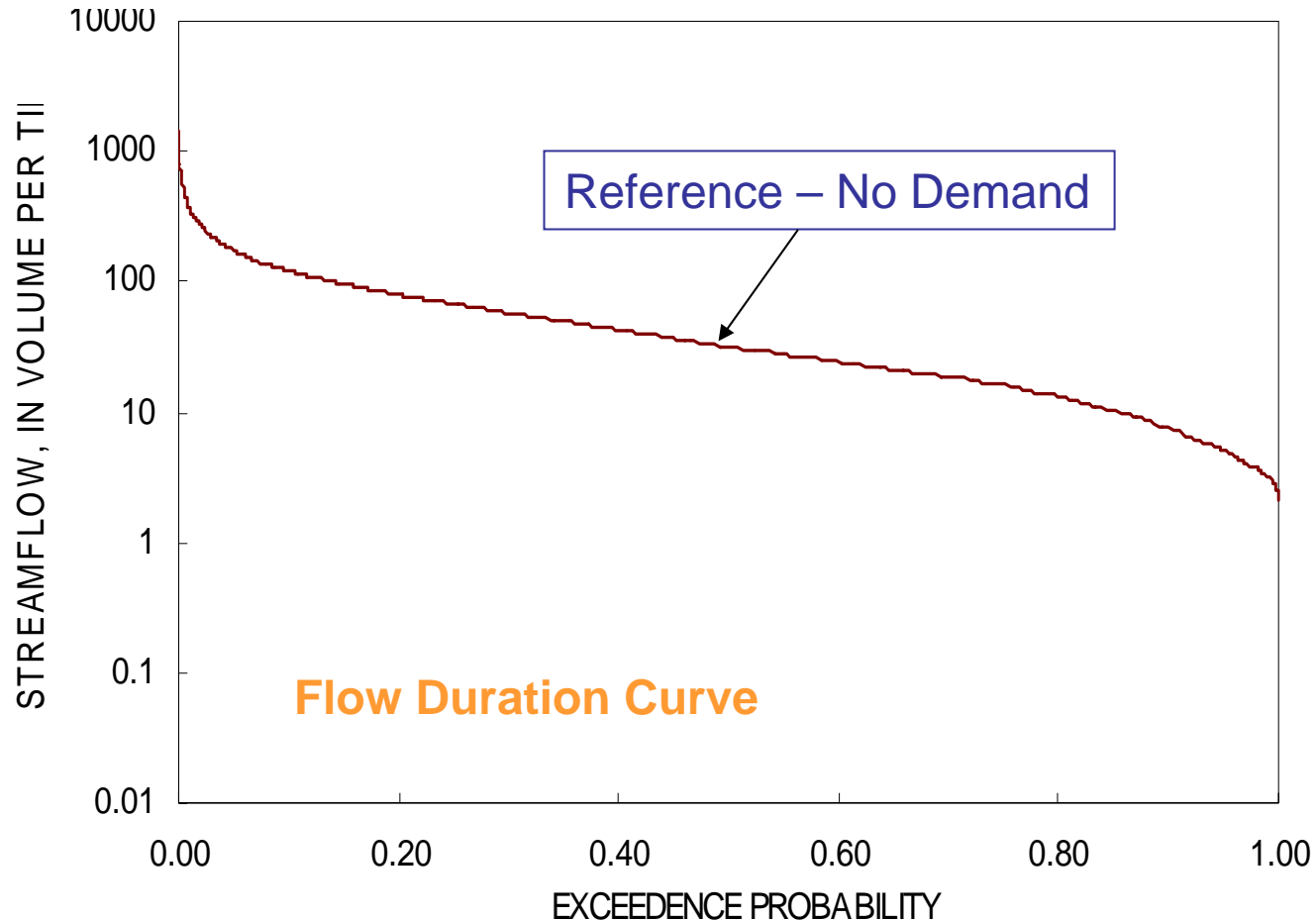


# Quantifying Trade-offs and Key Variables

1. The relationship between water supply yield and flow requirements;
2. Small reservoirs behave differently than large reservoirs;
3. Same yield can result in different flows;
4. Measuring trade-offs between policy objectives
5. Drought management increases overall

# Same Yield but.....

## Different Instream Flow Outcomes

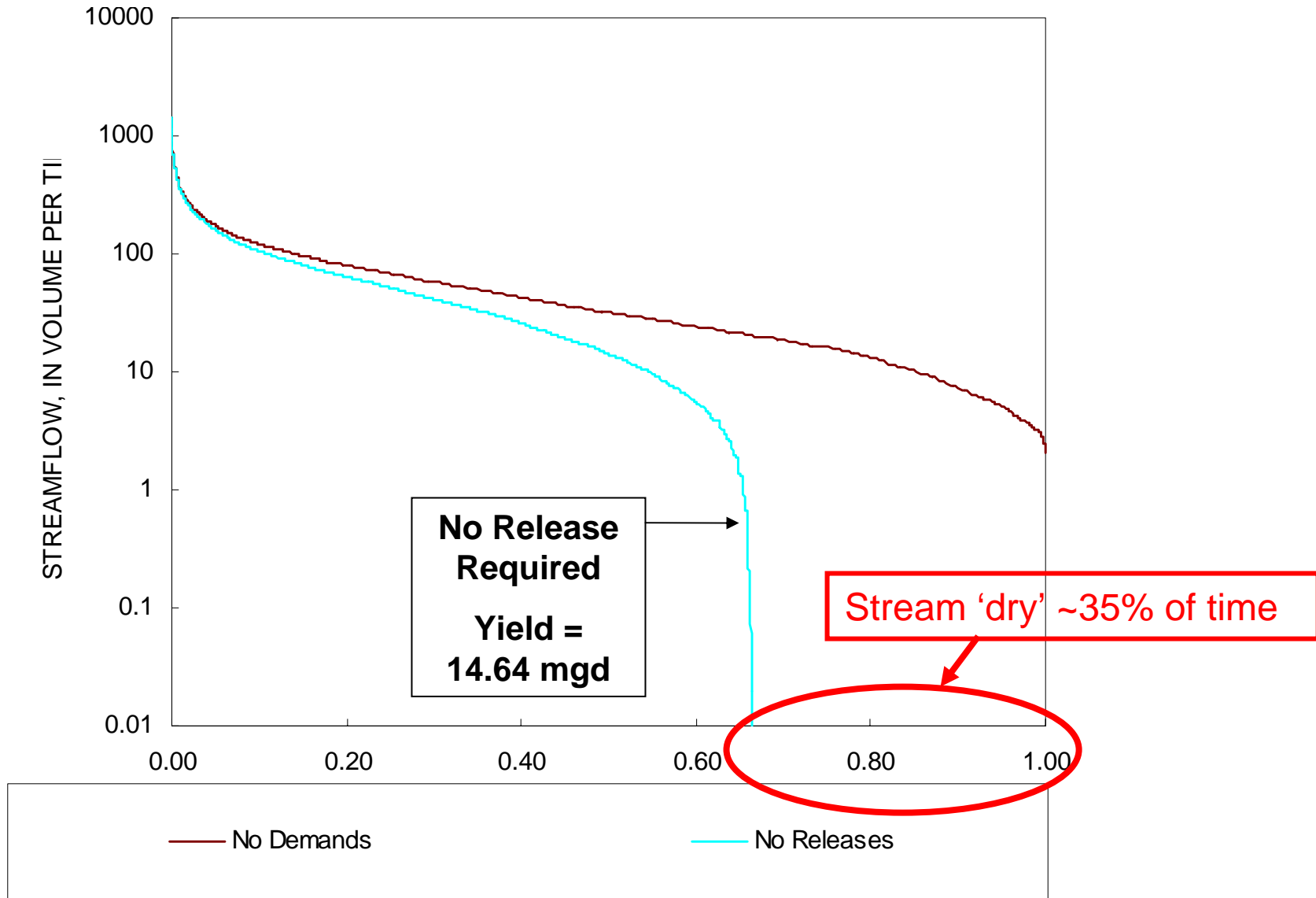


— No Demand



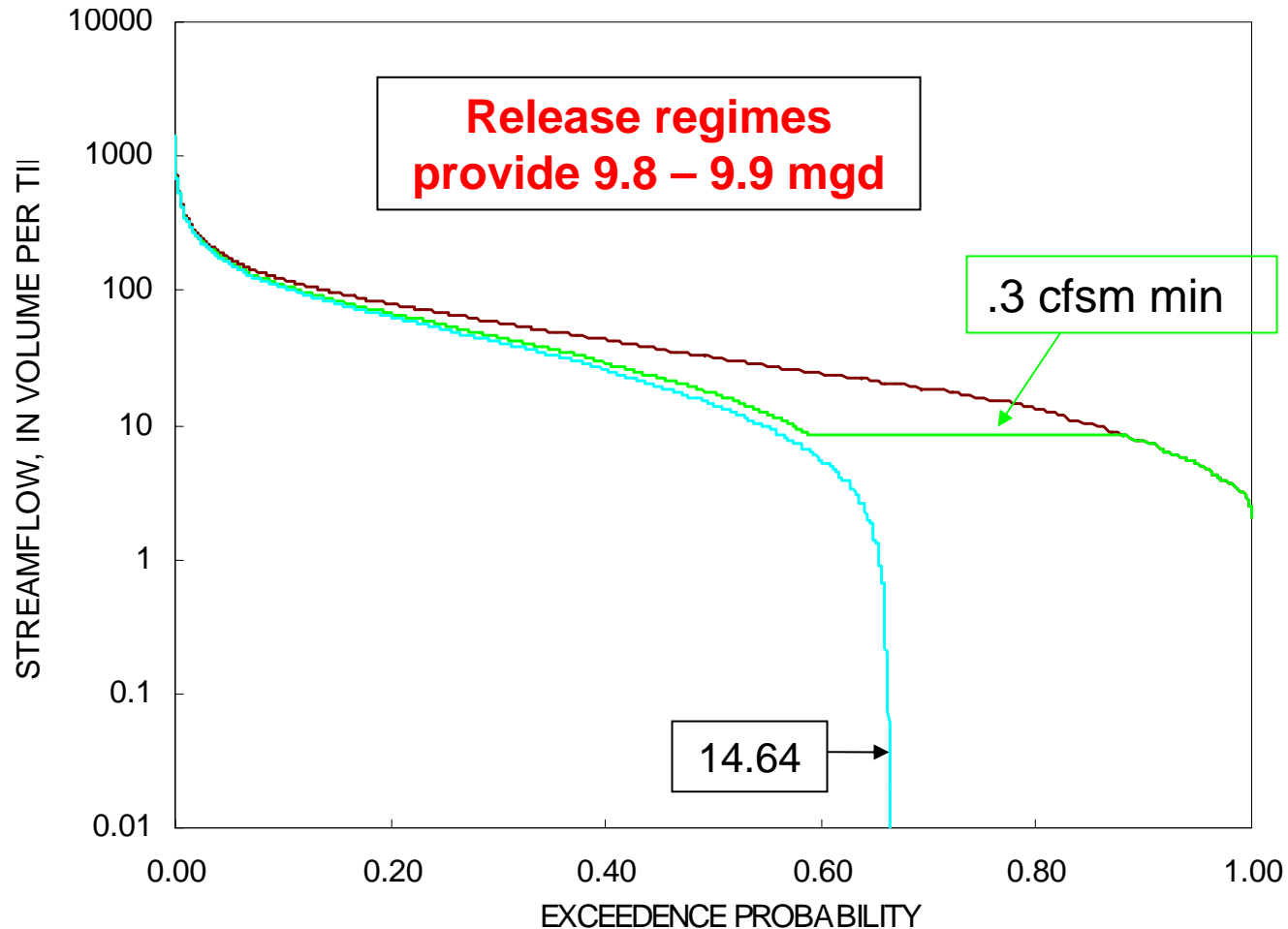
# Same Yield but.....

## Different Instream Flow Outcomes



# Same Yield but.....

## Different Instream Flow Outcomes



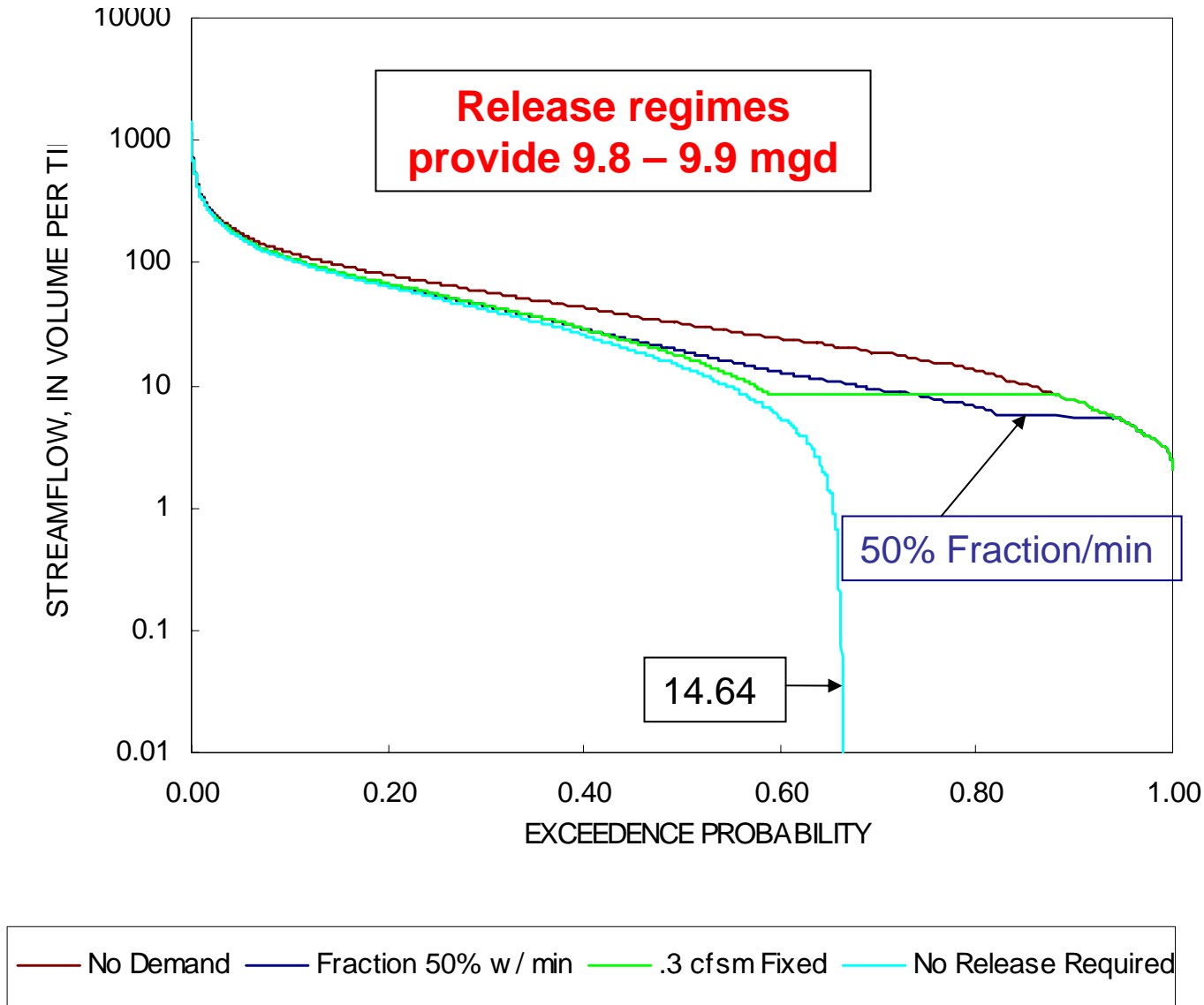
— No Demand

— .3 cfsm Fixed

— No Release Required

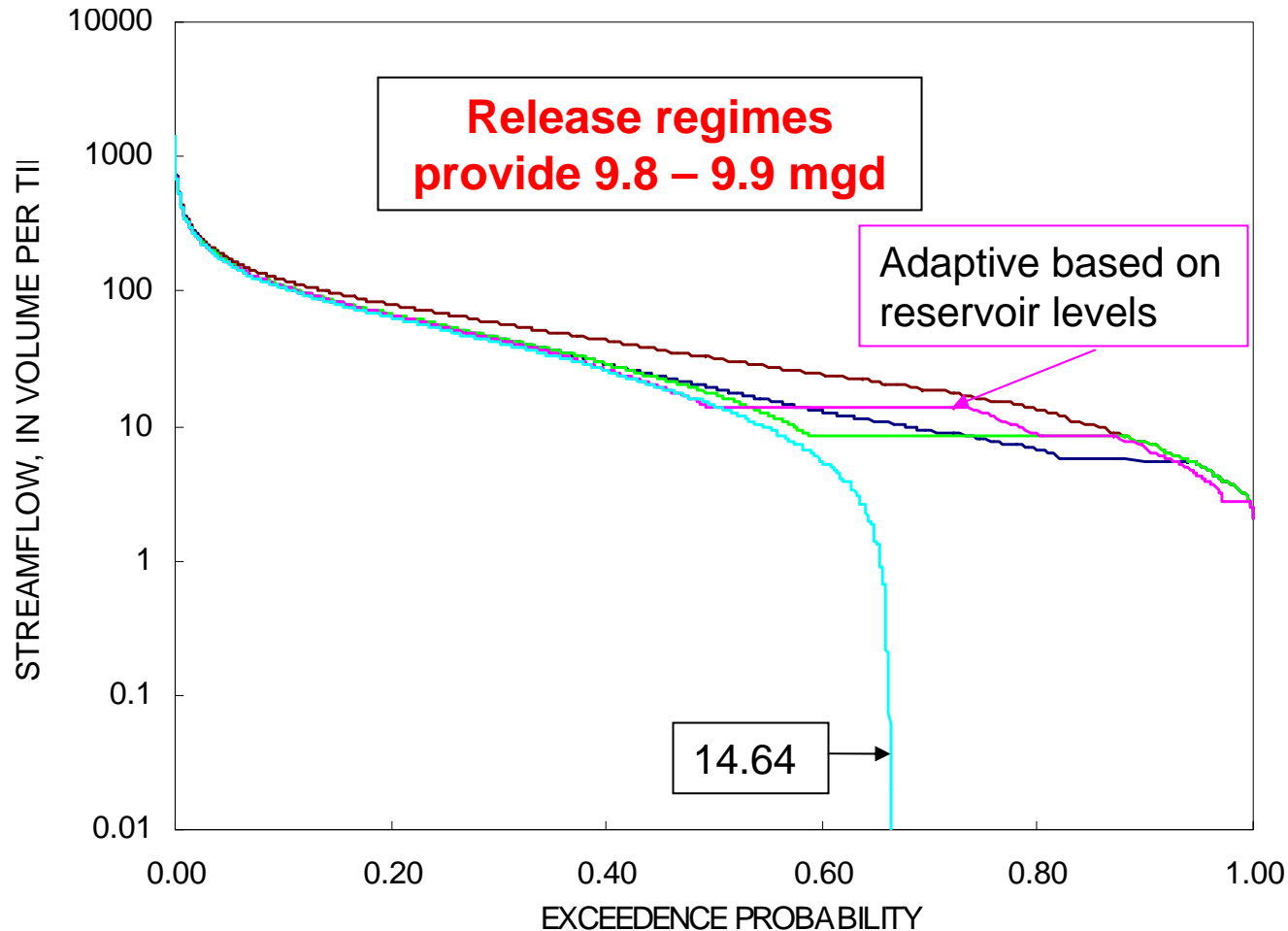
# Same Yield but.....

## Different Instream Flow Outcomes



# Same Yield but.....

## Different Instream Flow Outcomes



— No Demand	— Fraction 50% w/ min	— .3 cfsm Fixed
— Adaptive - Fixed .5	— No Release Required	



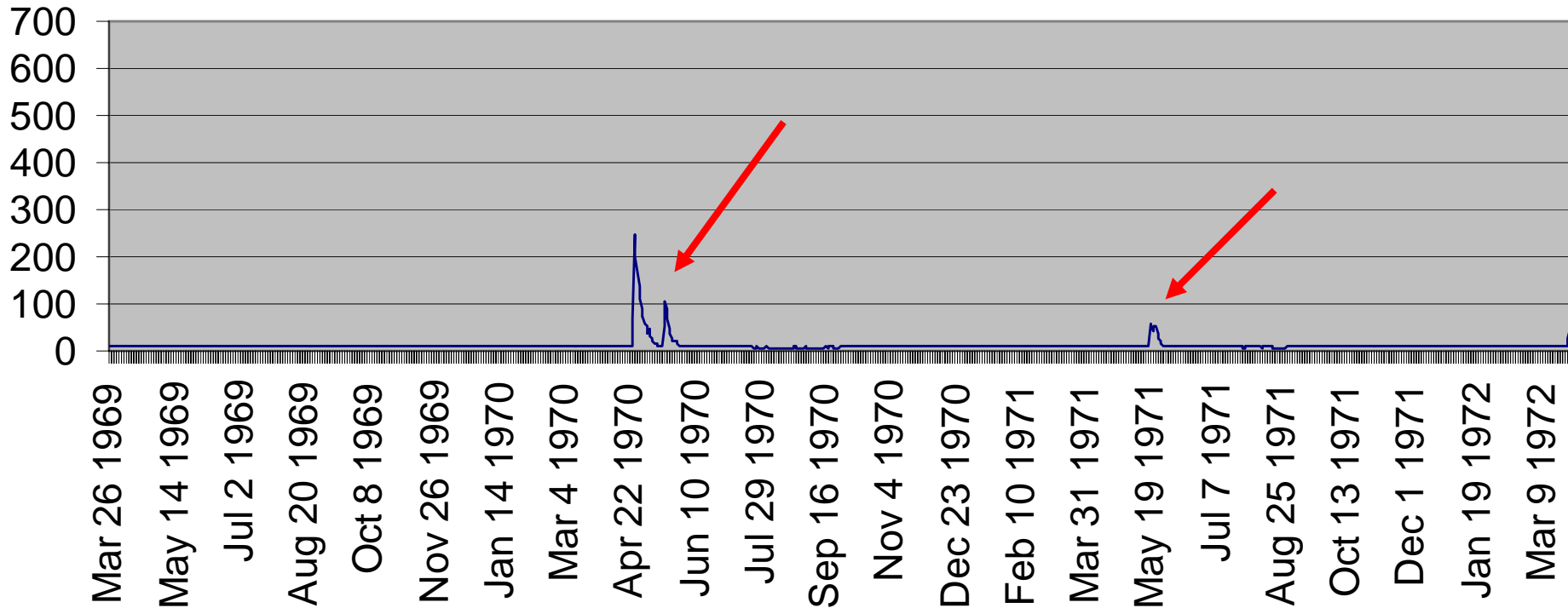


# Quantifying Trade-offs and Key Variables

1. The relationship between water supply yield and flow requirements;
2. Small reservoirs behave differently than large reservoirs;
3. Same yield can result in different flows;
4. Measuring trade-offs between policy objectives
5. Drought management increases overall

# Trade-offs Between Release Policies

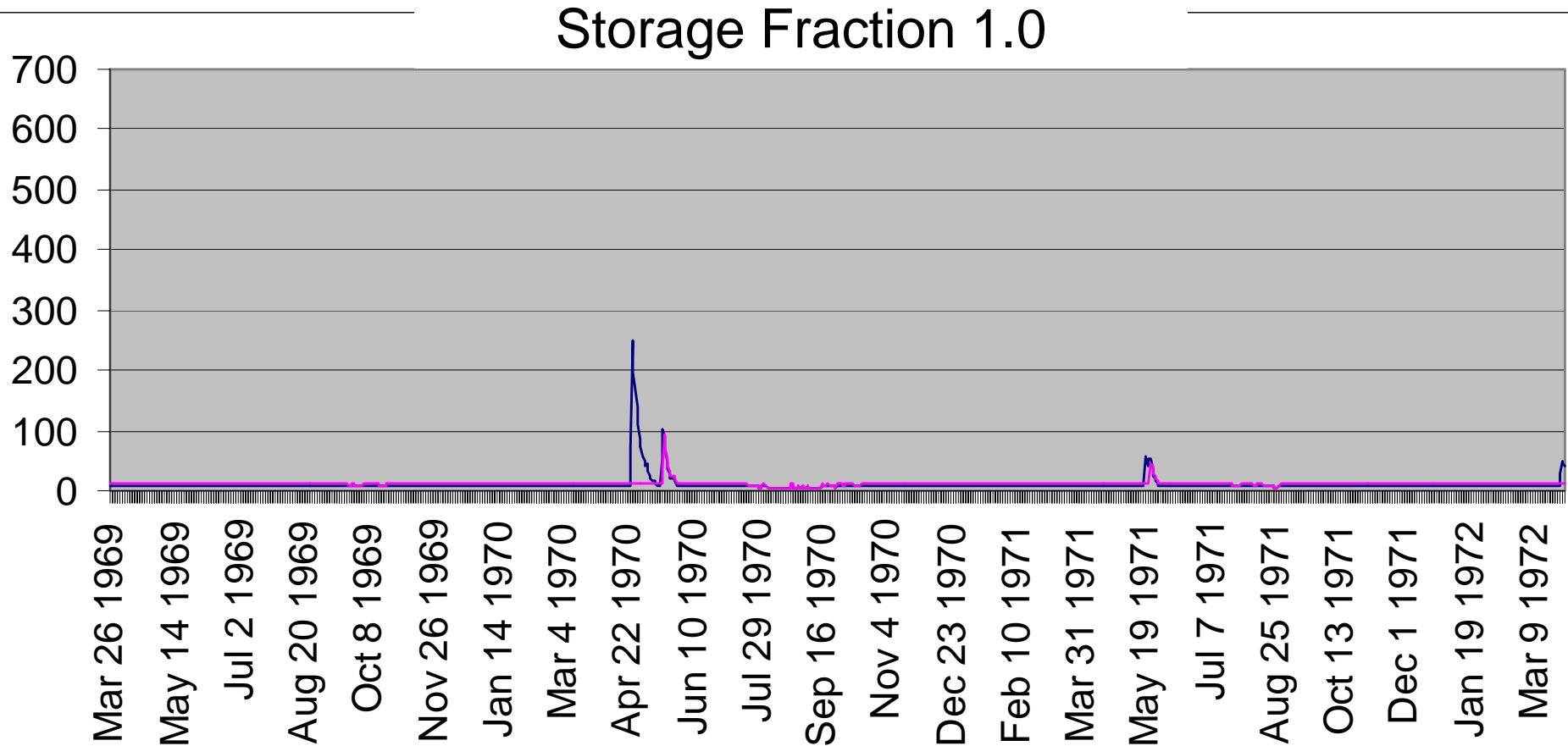
Storage Fraction 1.0



.3 cfs minimum flow

Fixed Minimum Flows reduce number of peaks

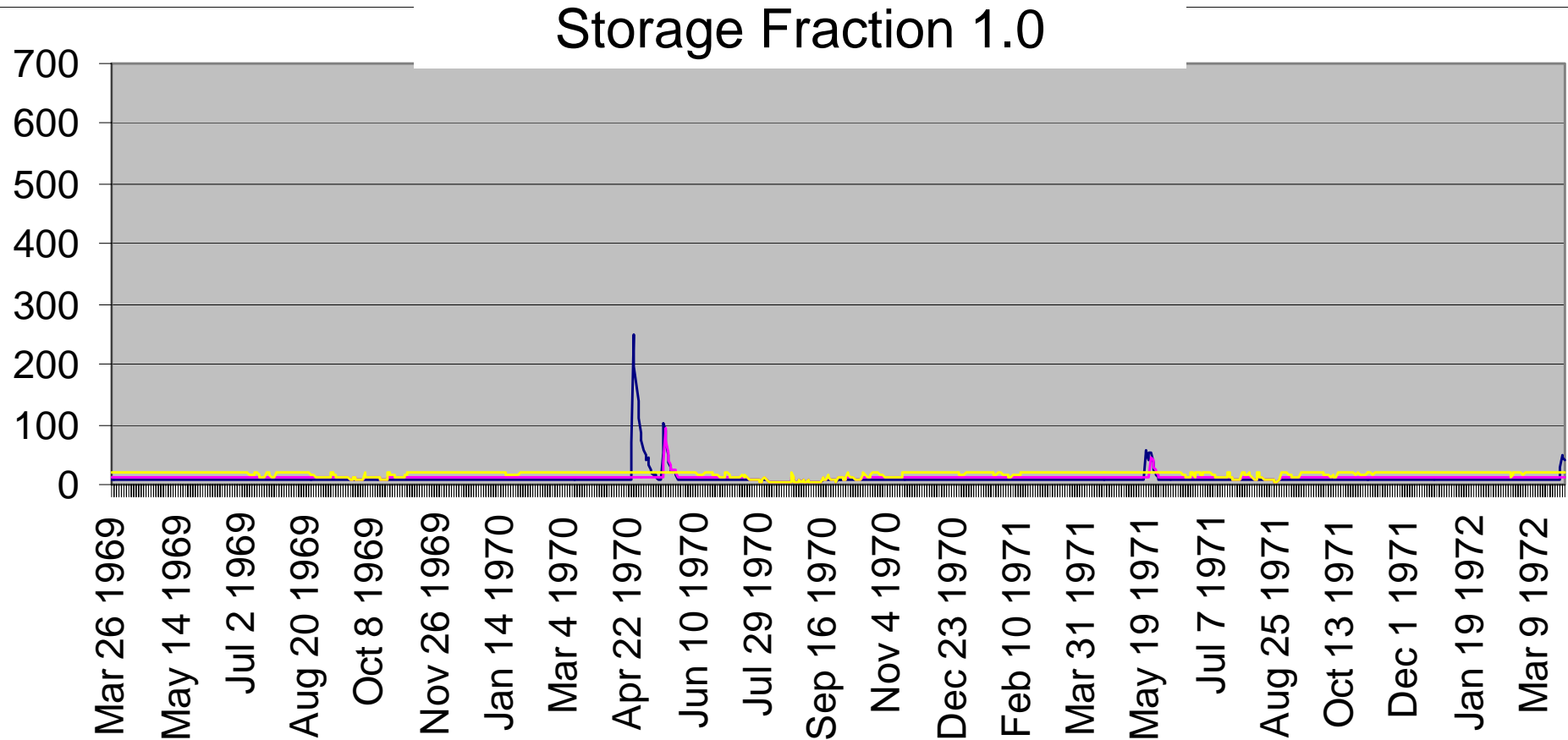
# Trade-offs Between Release Policies



.5 cfs minimum flow

Higher minimum flows = fewer and smaller

# Trade-offs Between Release Policies

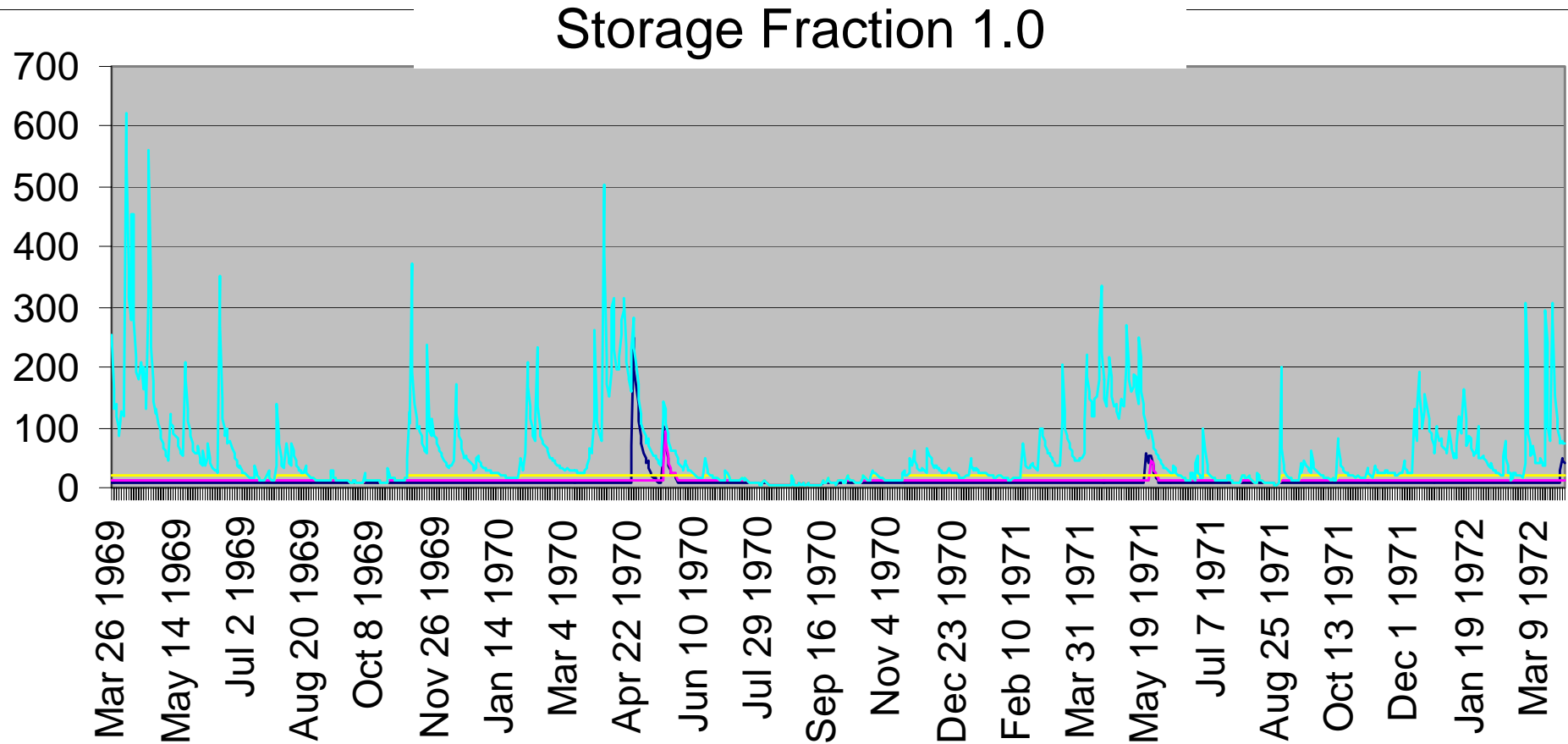


.7 cfs minimum flow

Higher minimum flows = can eliminate many



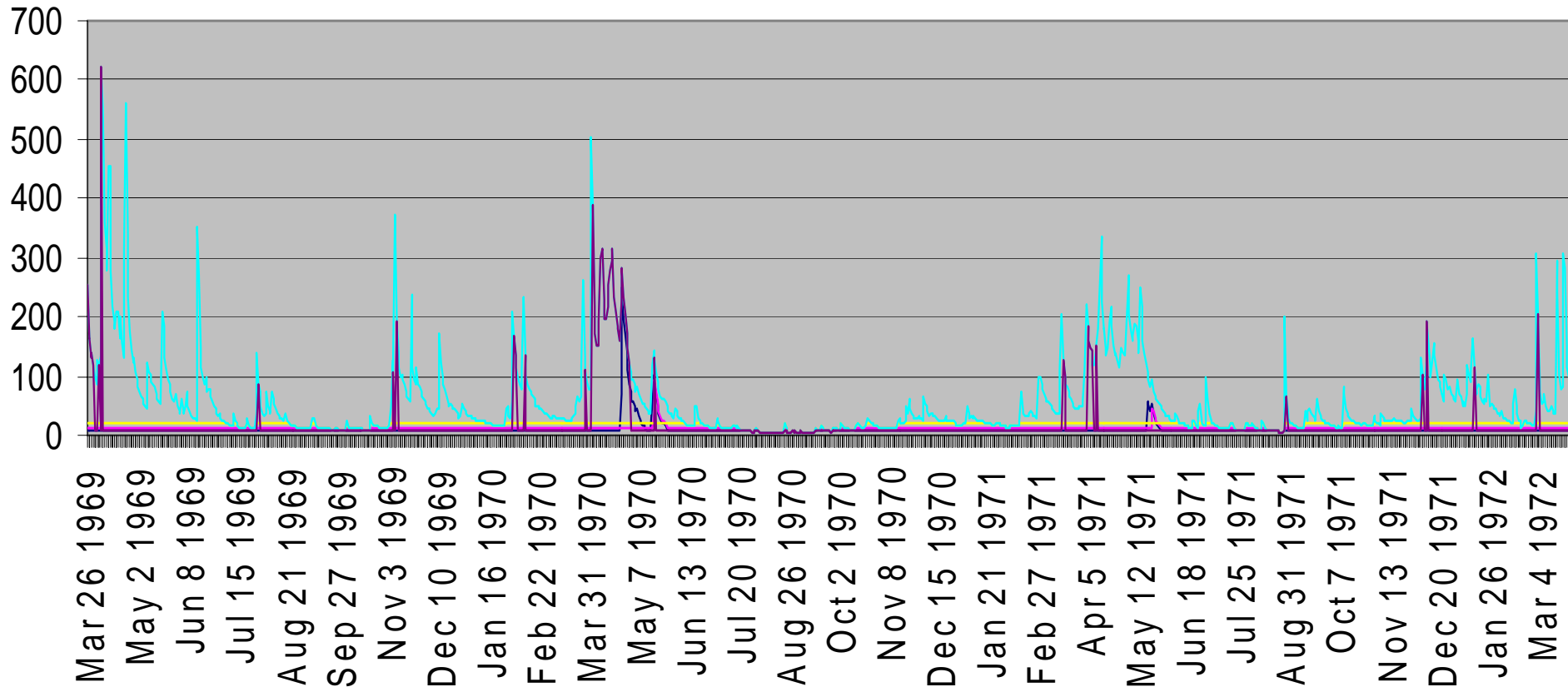
# Trade-offs Between Release Policies



Especially compared to natural flow regimes

# Trade-offs Between Release Policies

Storage Fraction 1.0



Can manage to include 'high flow pulses' to restore some high flows to managed systems



## As a result of CNS support we.....



- Developed a tool that allows the testing of different reservoir management and water use policies;
- Increased our understanding of how state water management policies can be crafted to meet multiple objectives;
- Helped develop a new metric of changes to streamflow (eco-deficit).



## Feedback we want.....



- Ideas for summarizing multi-variate analysis (i.e. changes to streamflow) – are there good models from other disciplines
- How to efficiently communicate results to numerous federal and state agencies;
- Beyond publishing in peer-reviewed journals, what documentation will be most useful;
- Ideas for case studies where we might work with stakeholders to apply our methods;



# Possible Outcomes

Ensuring “safe yield” calculations  
include environmentally sustainable  
stream flows

Supporting efforts of state governments  
to develop stream flow protection  
policies and programs

Developing new measures to  
understand changes to stream  
hydrology



# Integrating Water Supply And Ecological Flow Requirements

**Funding Provided By:**

**U.S. Environmental Protection  
Agency**

**Collaborative Science and Technology  
Network for Sustainability**

**EPA Grant # X3-83238601-0**

“Nature always wears the colors of the spirit” —EMERSON



# Integrating Water Supply And Ecological Flow Requirements

U.S. EPA Collaborative Science and Technology  
Network for Sustainability Progress Review  
Meeting

December 5 & 6, 2006  
Washington, D.C.