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SAVING THE LAST GREAT PLACES ON EARTH

"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.

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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

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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

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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.

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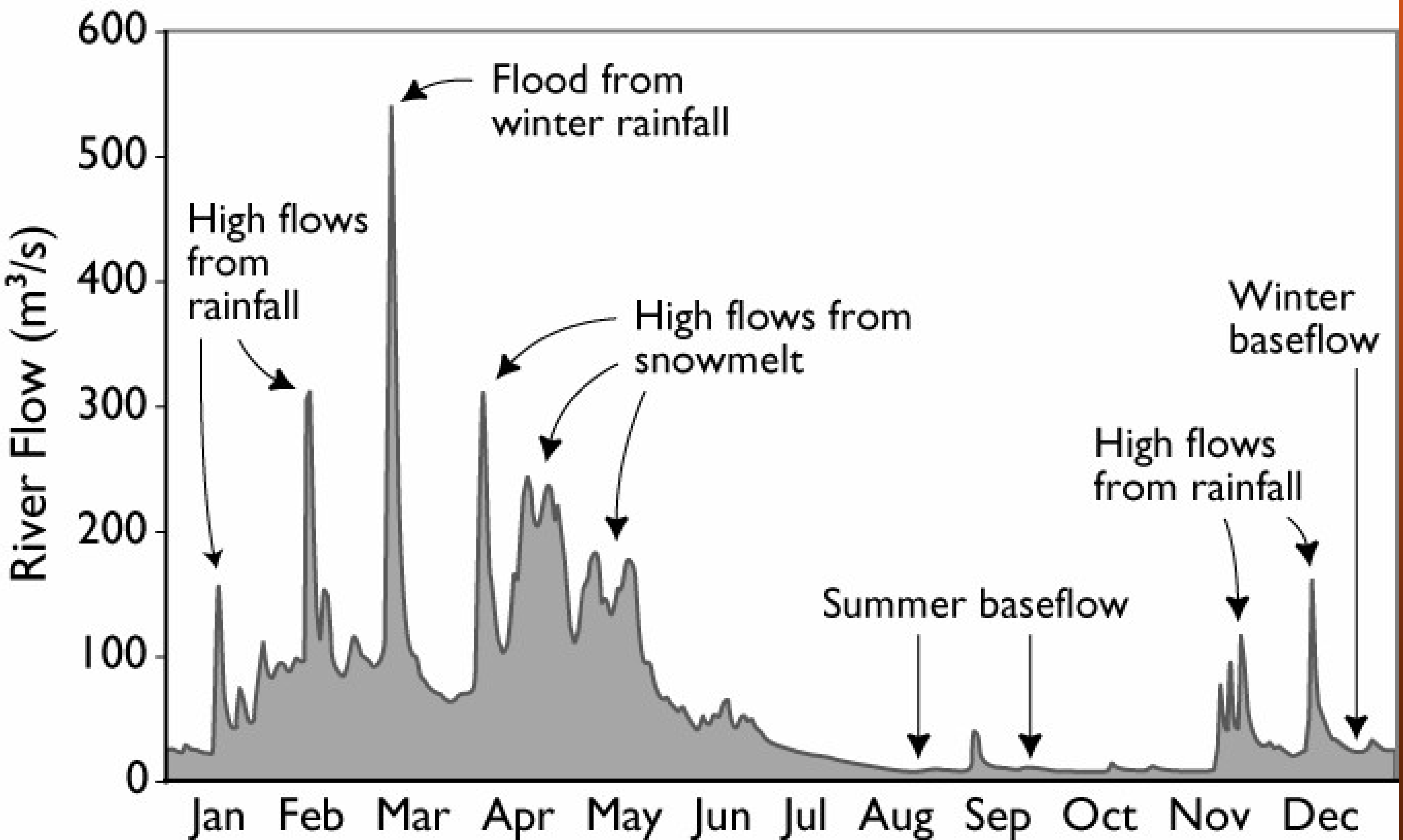
Natural Variability

Inter and Intra Annual Variations



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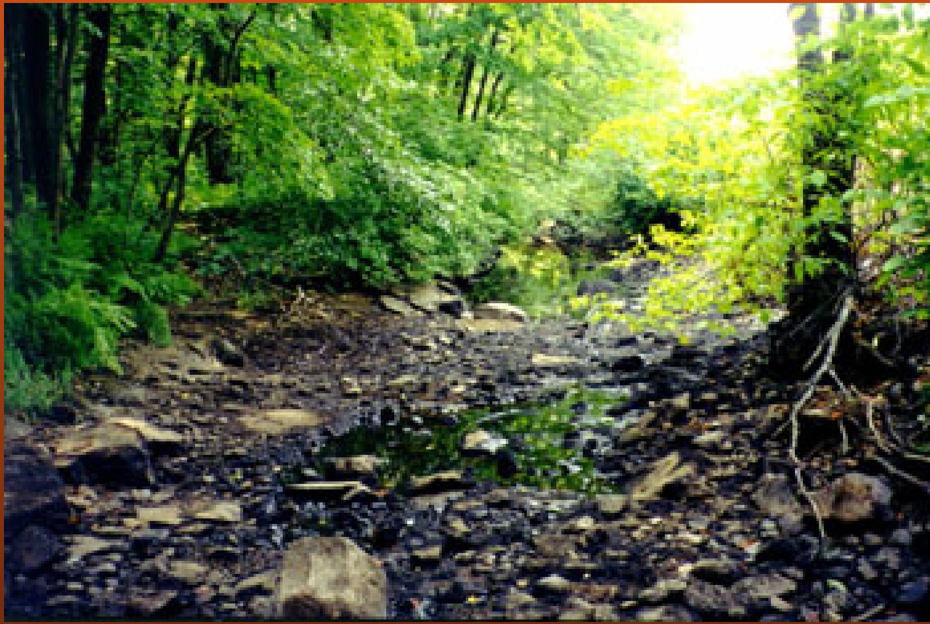
Project Context

Low Flow Conditions
Massachusetts

Fish Brook, Boxford



Sudbury River, Hopkinton

Photos from MA Riverways Program website

Project Context

Natural variations in precipitation can result in problems for water supplies

Middleton Pond, Massachusetts

Wenham Lake Massachusetts

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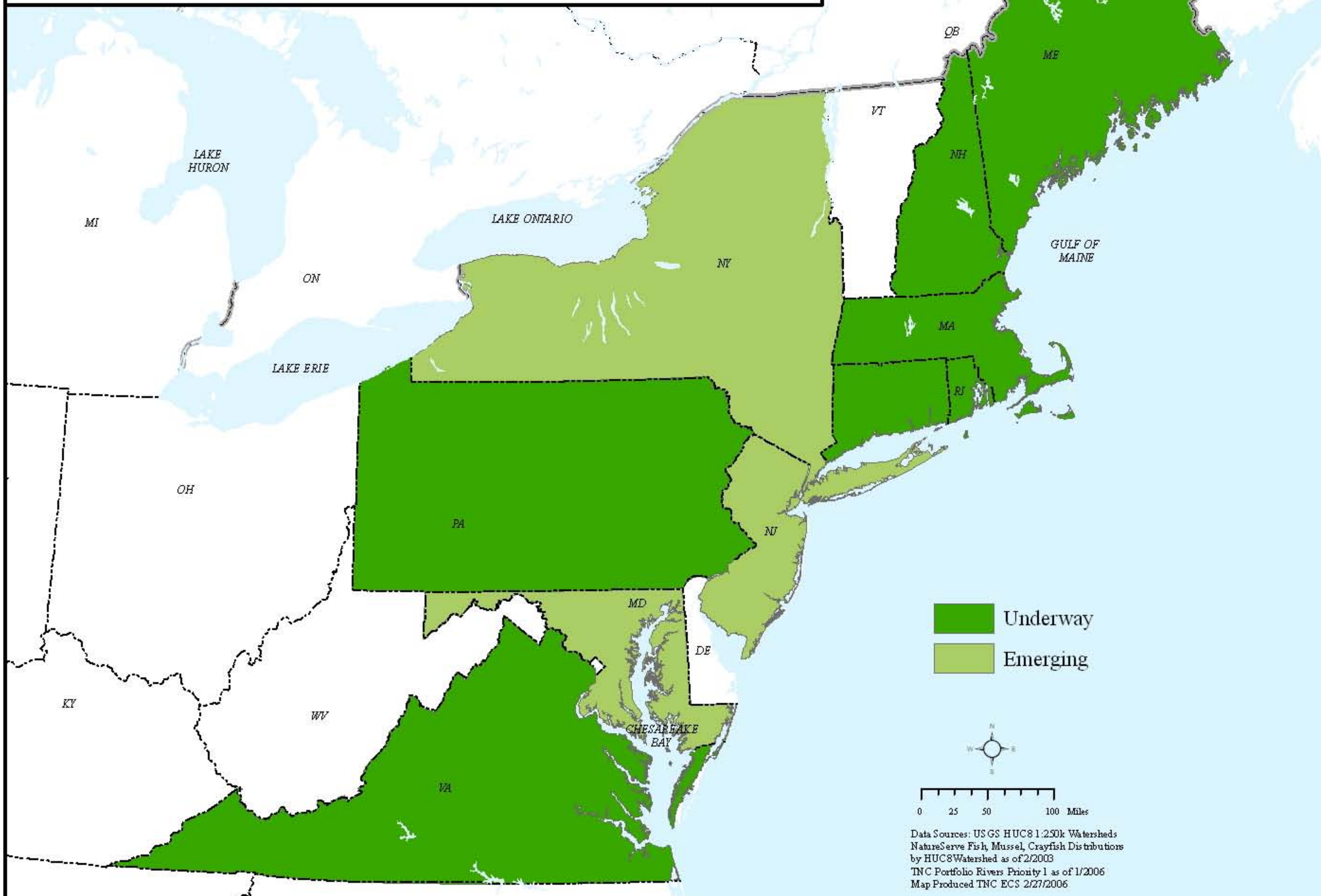
Eastern United States Freshwater Program

States Working on Instream Flow Policy

DRAFT OF 10/1/2006



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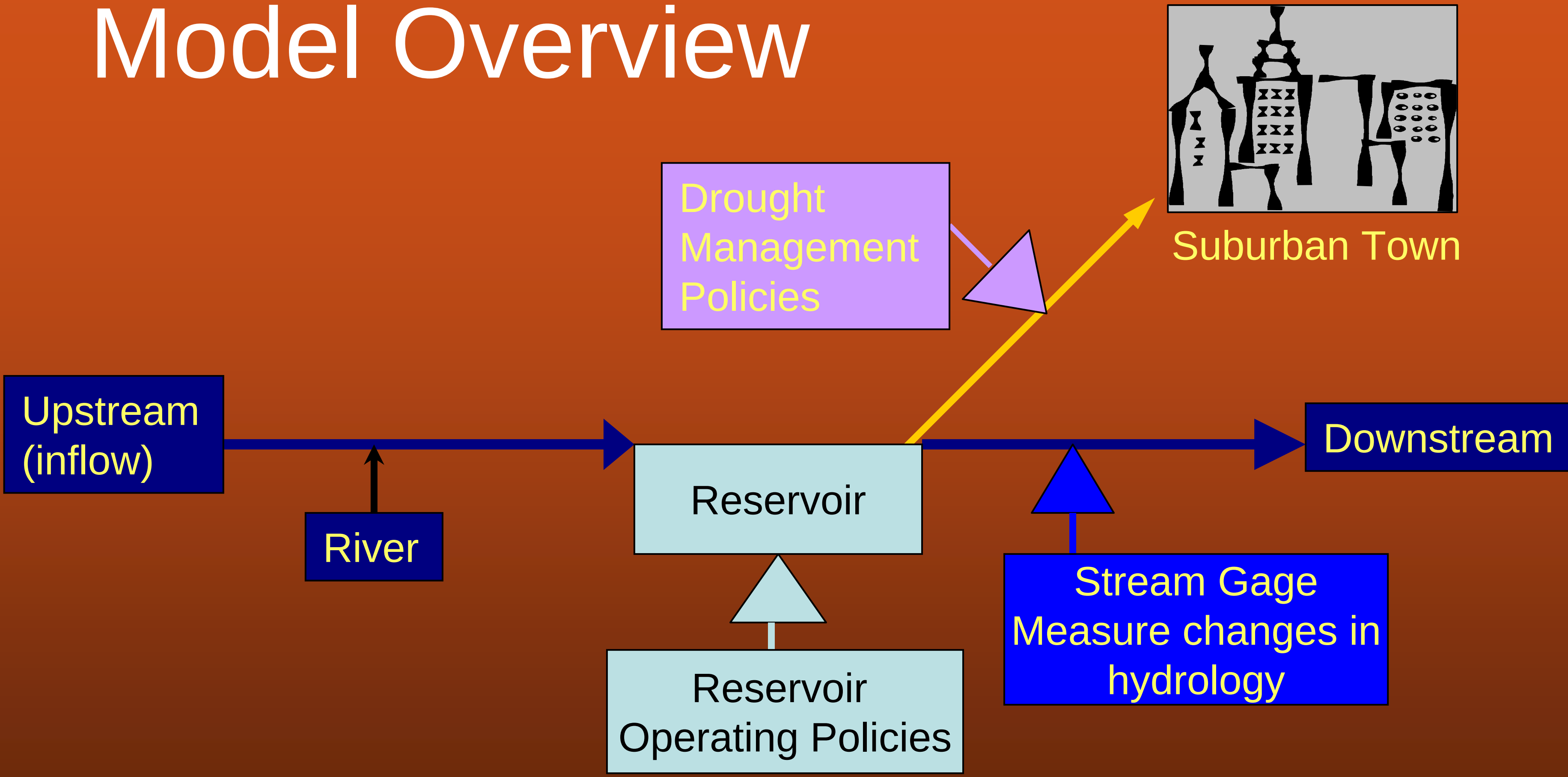
Model Overview



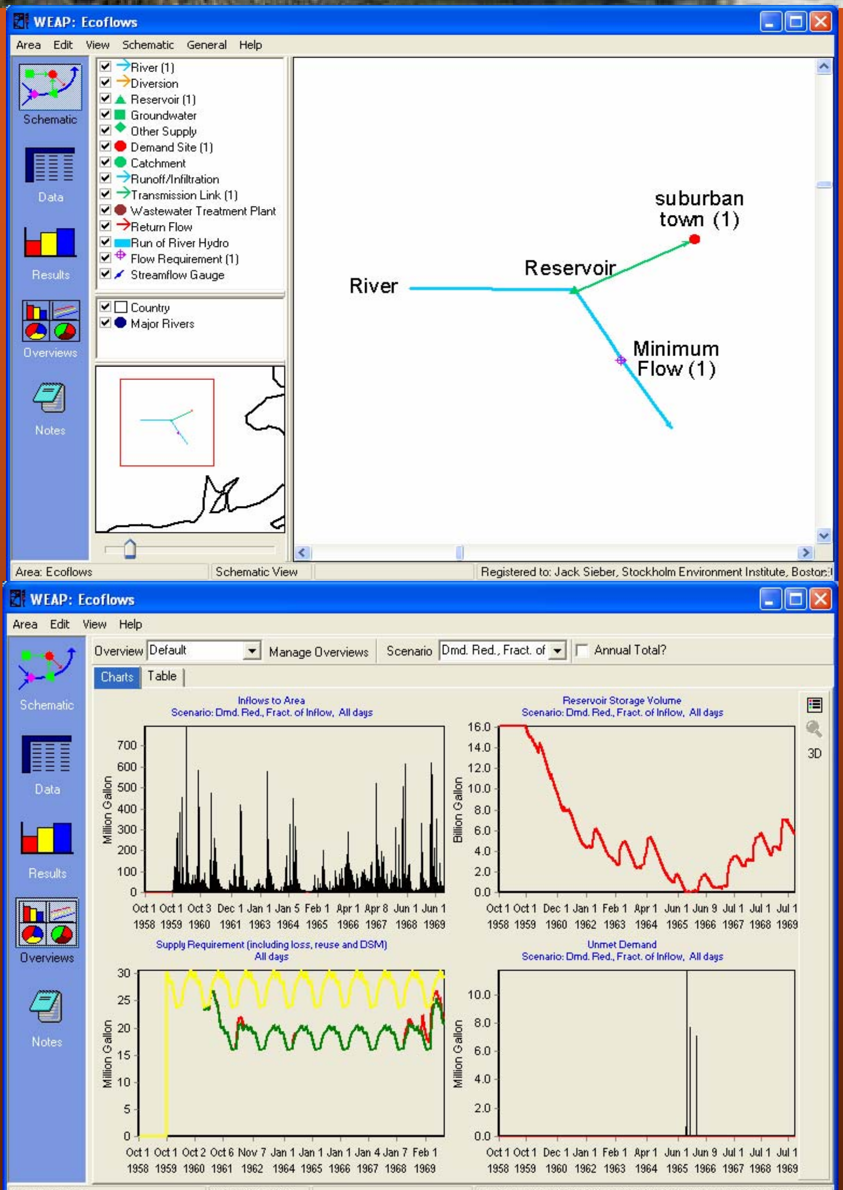
Some initial lessons learned

- 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

Project Platform

Water Evaluation and Planning model (WEAP)

Developed by Stockholm Environment Institute



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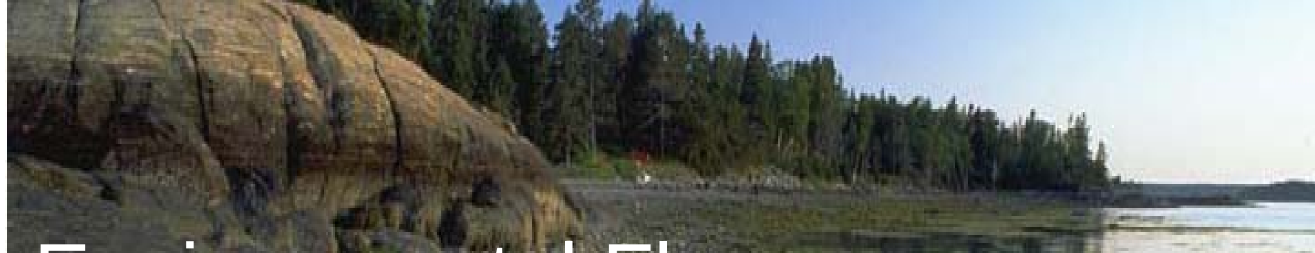

Incorporating Environmental Flow Requirements into Water Supply Management

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

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Measures

Flow:

Eco-deficit

Statistical software:

IHA

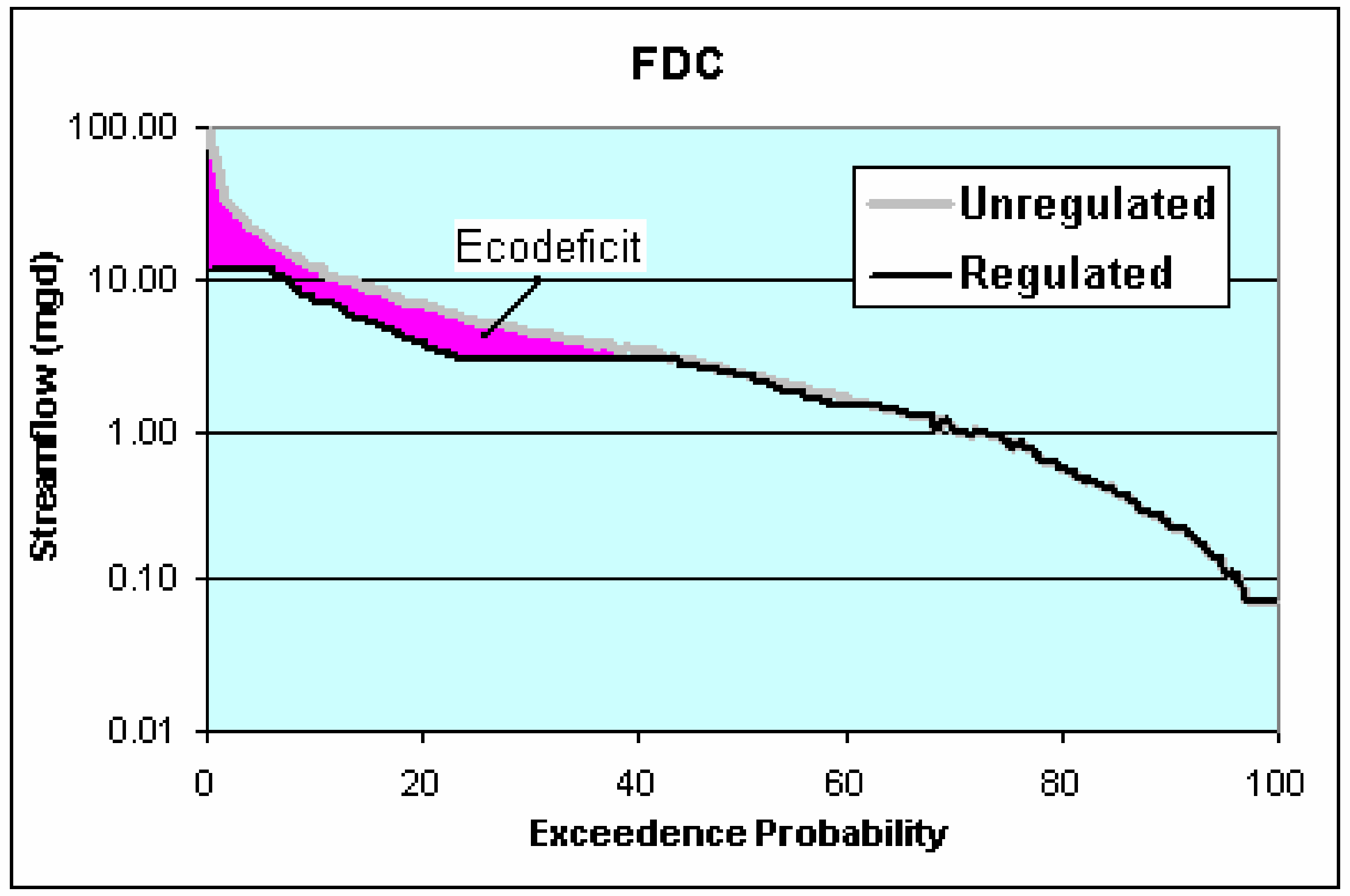
USGS HIP statistics

Water Supply:

- Yield
- Reliability
- Resilience

- Reservoir Size
  - Storage Fractions 1.0 and 0.1

Measuring the 'Ecodeficit'



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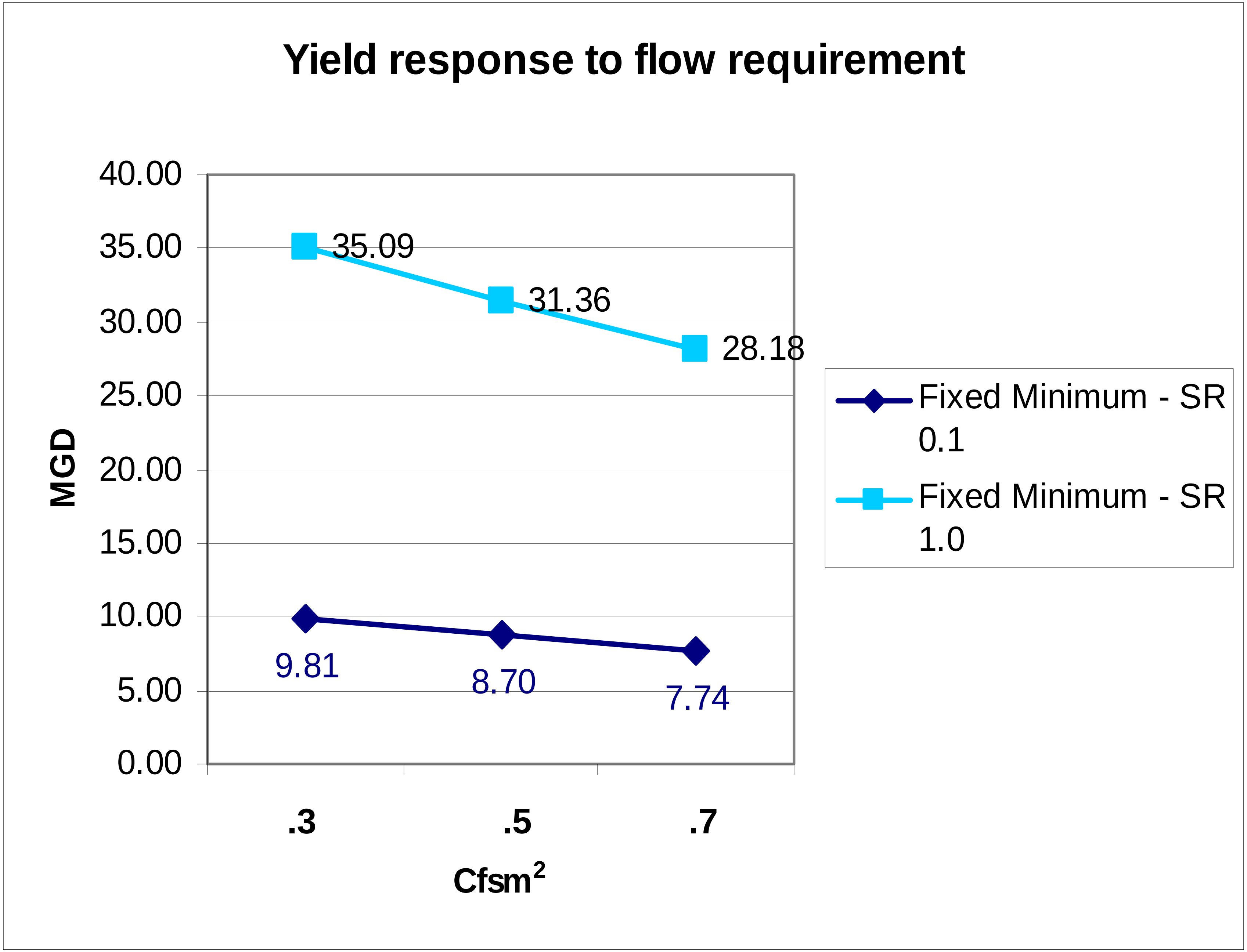
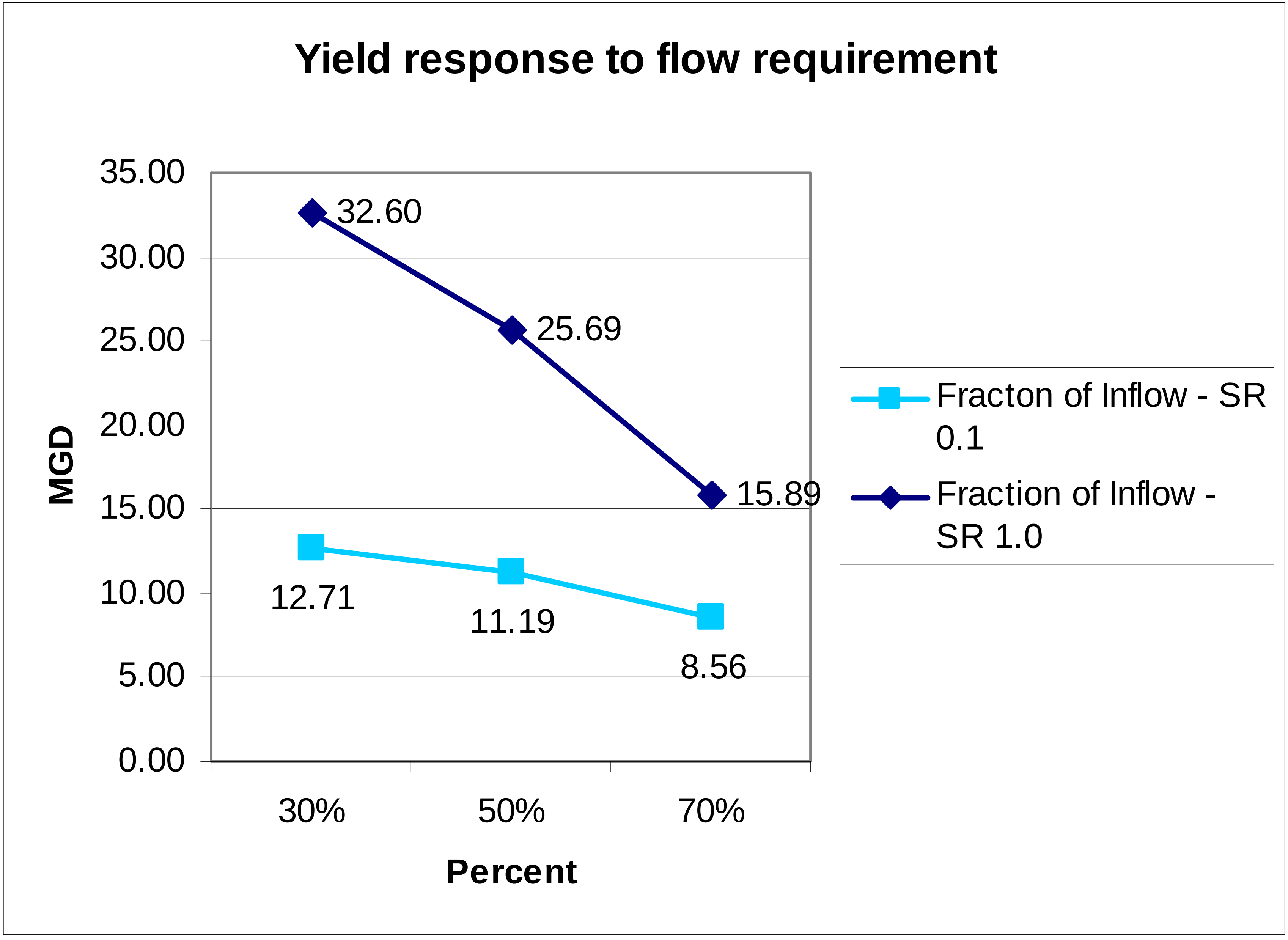
Quantifying Trade-offs and Key Variables

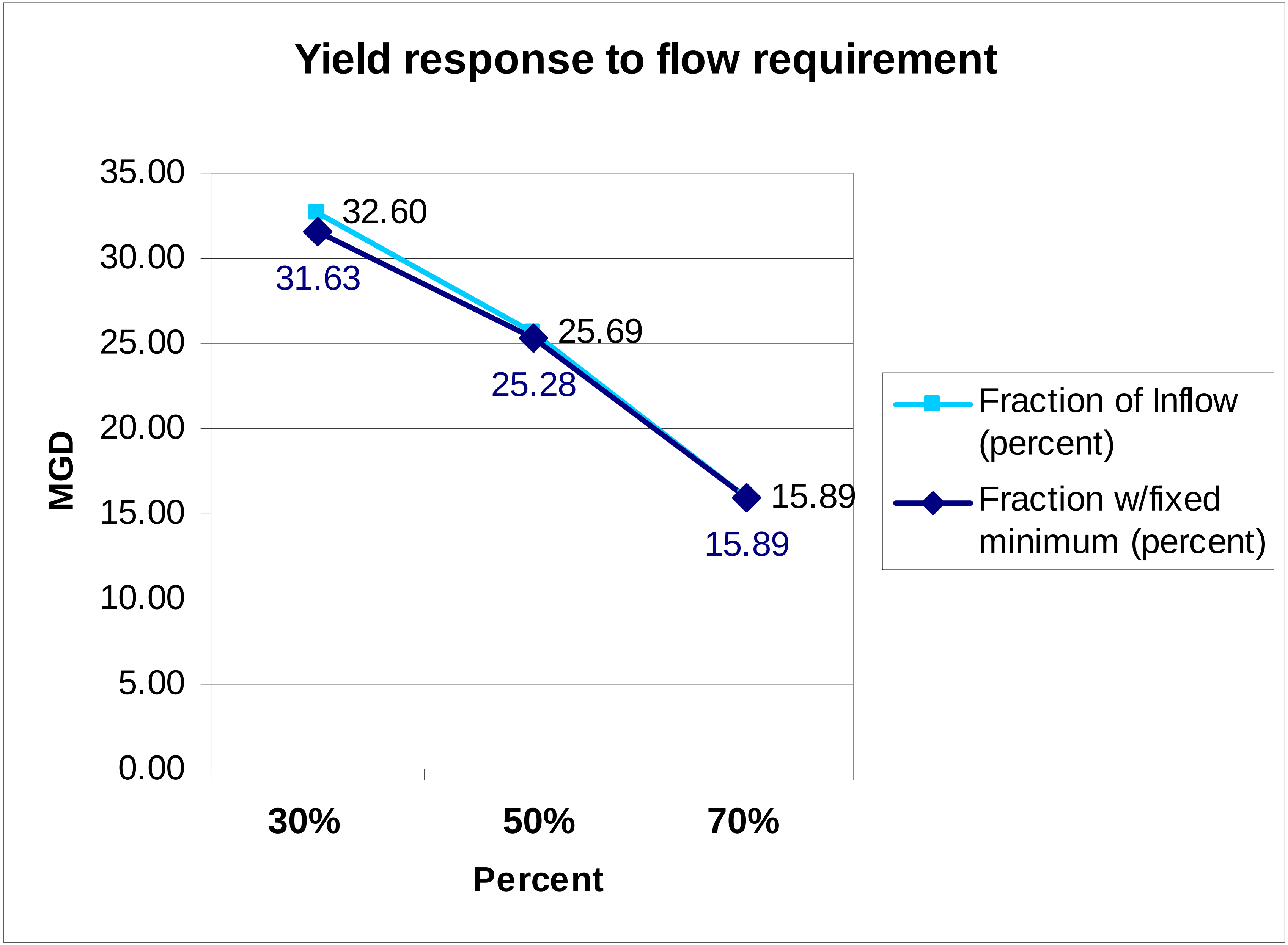
1. The relationship between water supply yield and flow requirements;
2. Small reservoirs behave differently than large reservoirs;
3. Same yield can result in different flows;
4. Measuring trade-offs between policy objectives
5. Drought management increases overall



Yield response to flow requirement
MGD
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
35.09
31.36
28.18
9.81
8.70
7.74
.3
.5
.7
Cfsm2
Fixed Minimum - SR 0.1
Fixed Minimum - SR 1.0



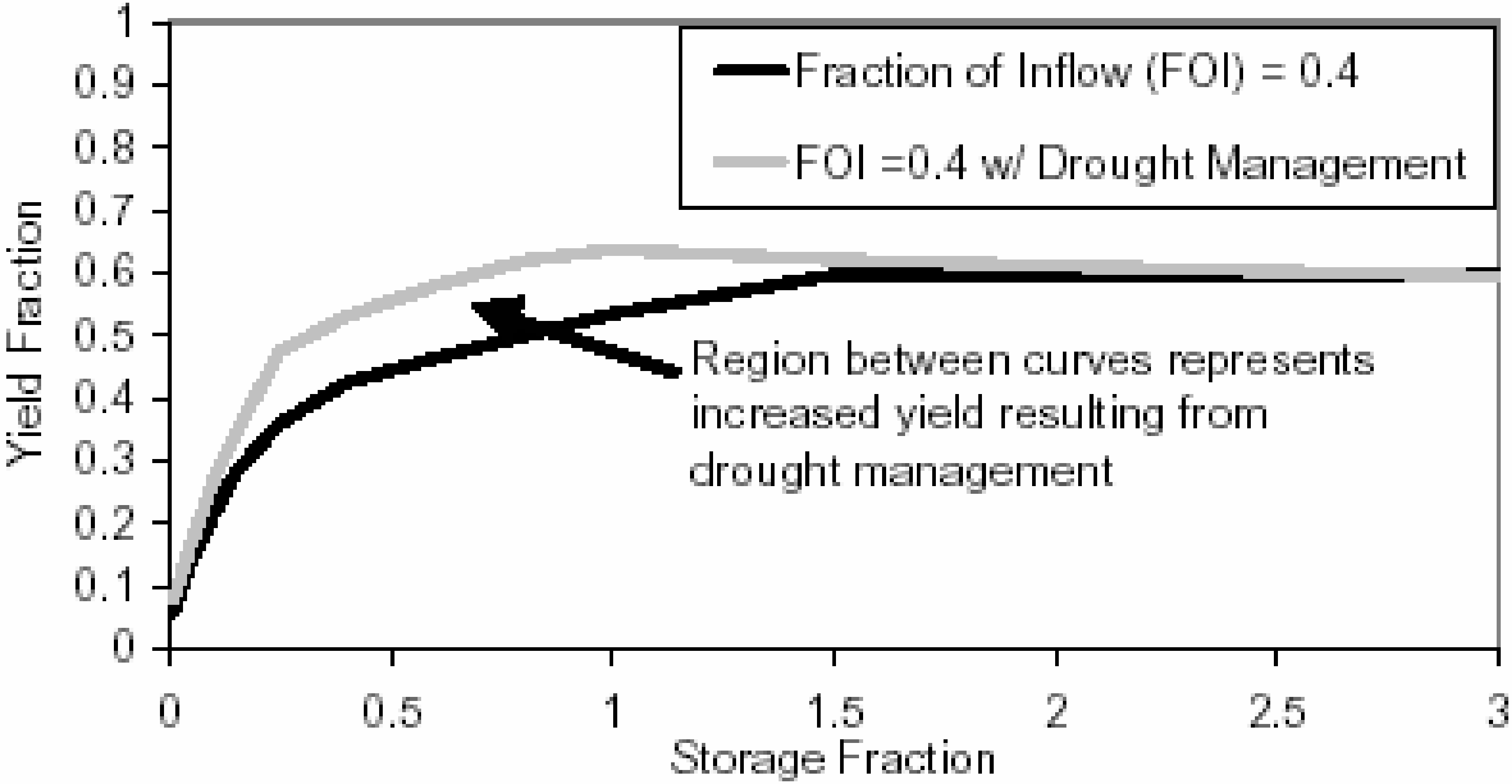
Yield response to flow requirement
MGD
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
32.60
25.69
15.89
12.71
11.19
8.56
30%
50%
70%
Percent
Fracton of Inflow - SR 0.1
Fraction of Inflow - SR 1.0



Yield response to flow requirement
MGD
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
32.60
31.63
25.69
25.28
15.89
15.89
30%
50%
70%
Percent
Fraction of Inflow (percent)
Fraction w/fixed minimum (percent)

Demand Management

Demand Management Increases the Yield of Water Supplies



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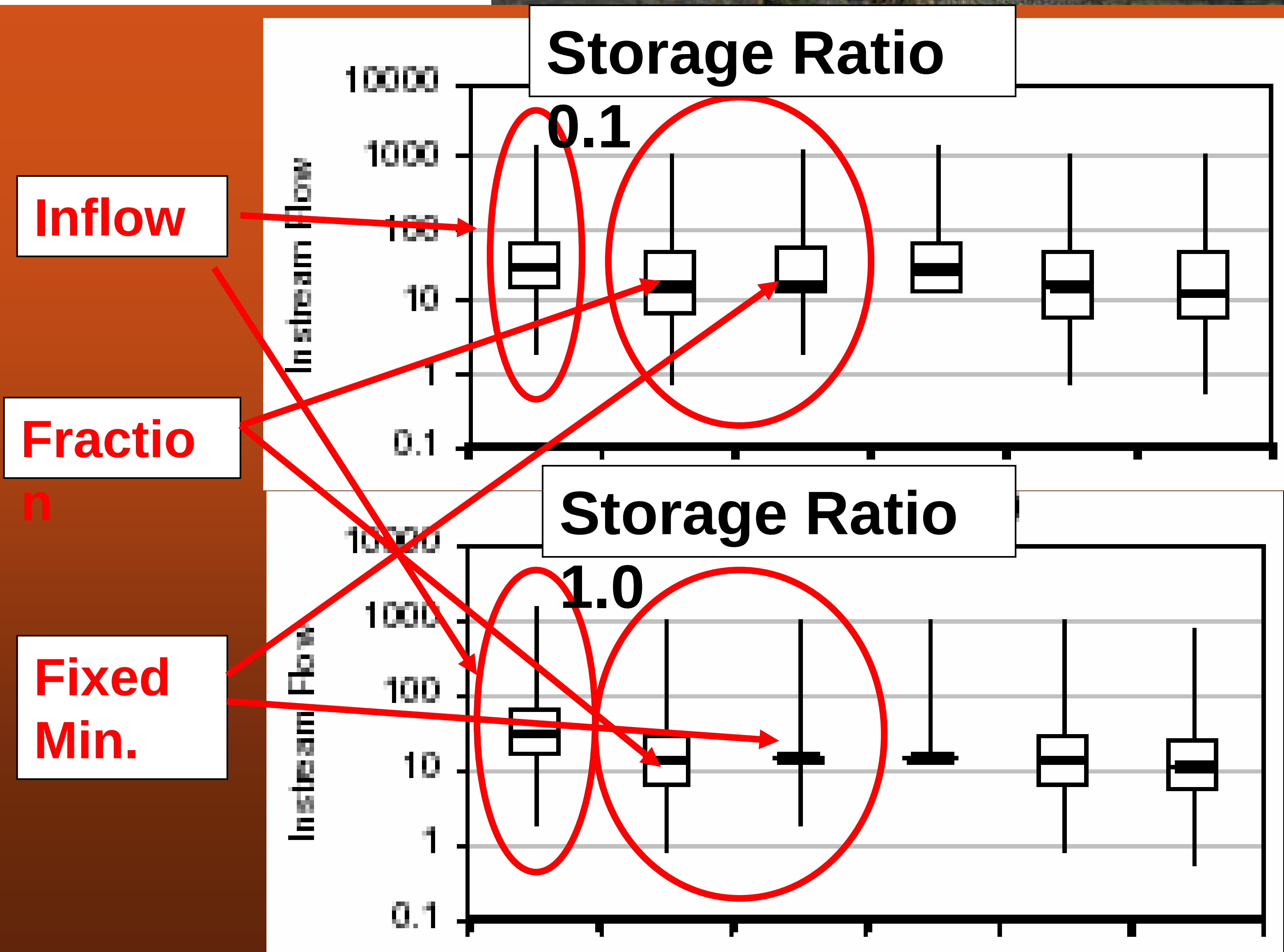
Reservoir Size



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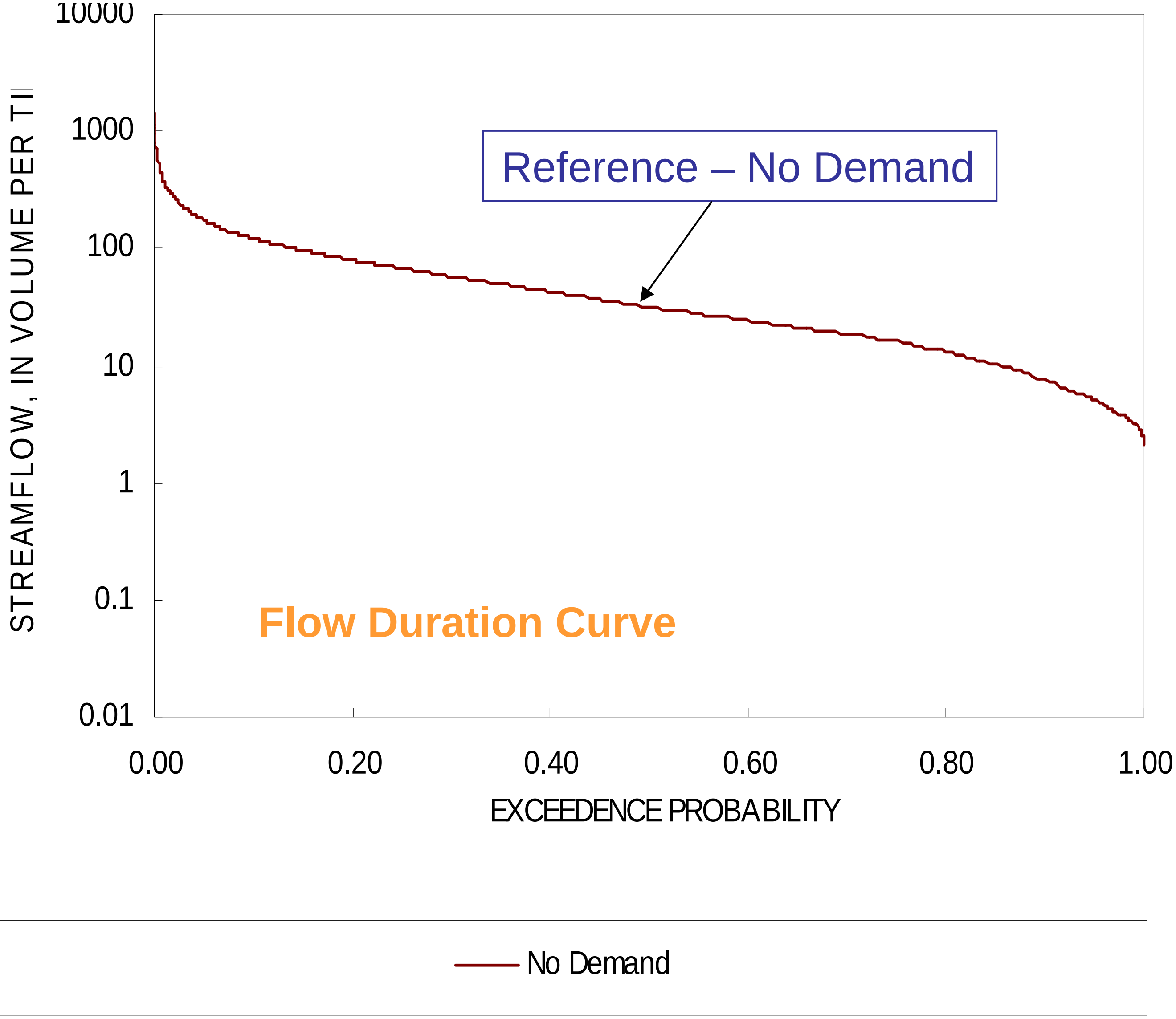
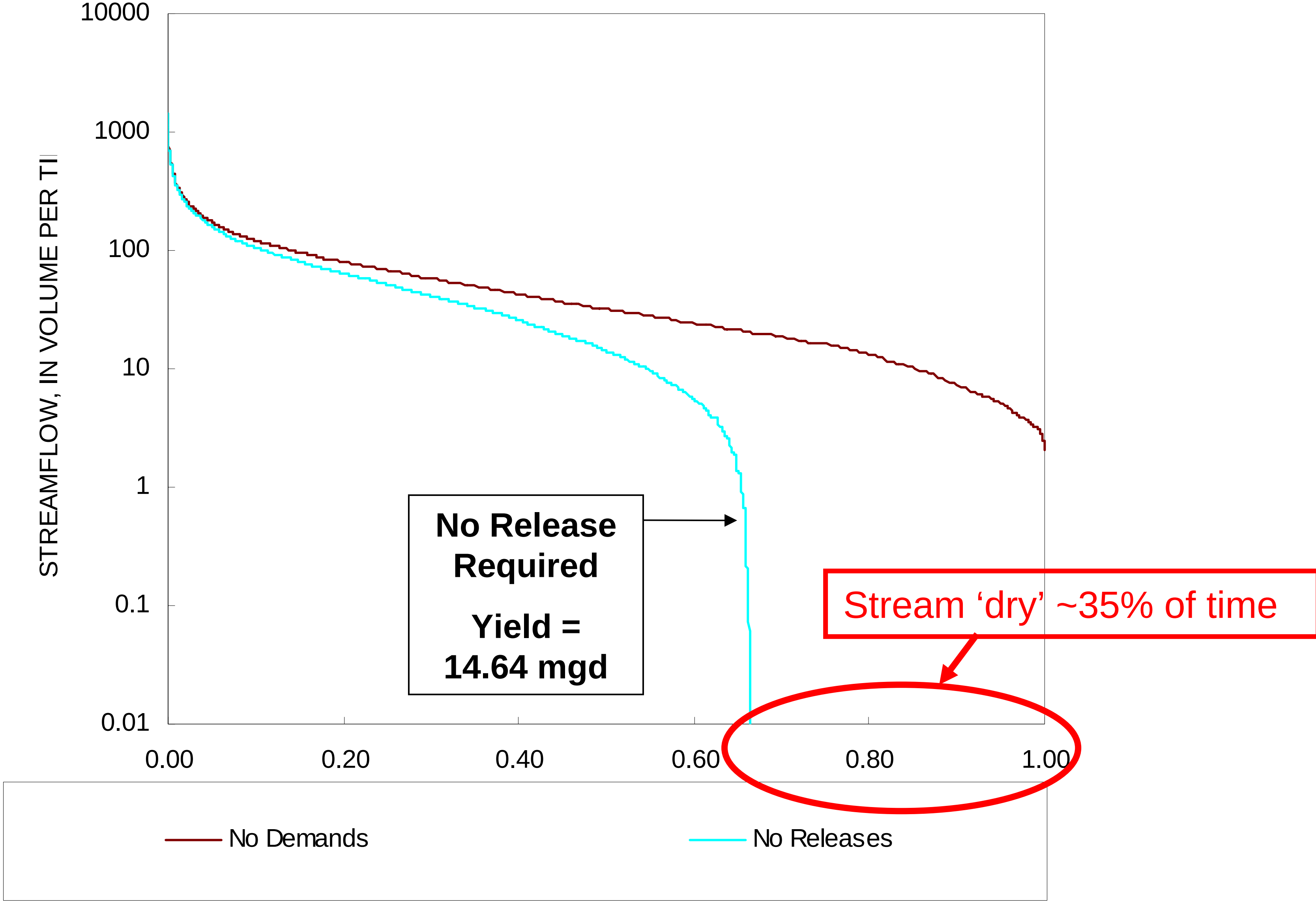
Same Yield but…..
Different Instream Flow Outcomes



Same Yield but…..
Different Instream Flow Outcomes



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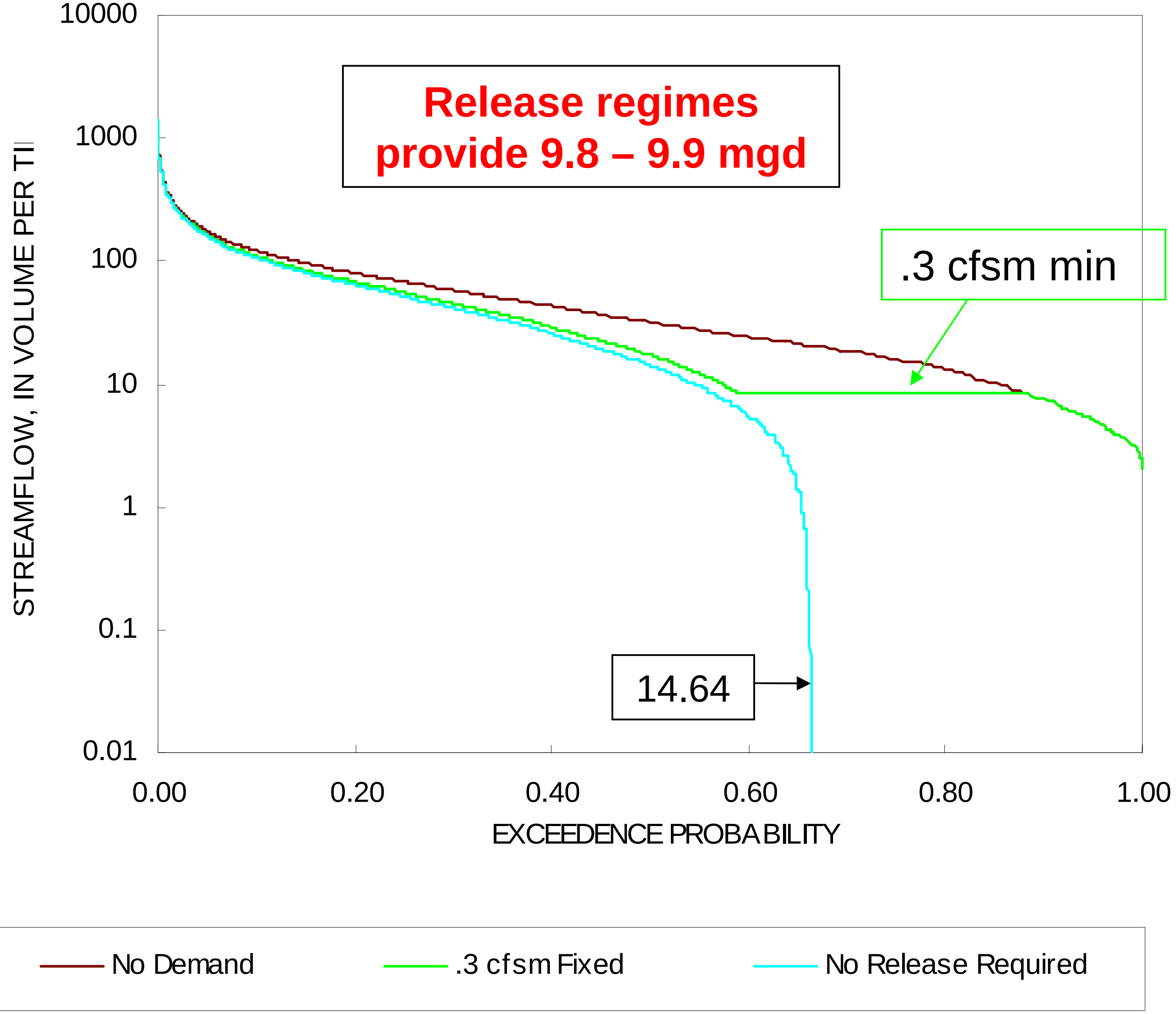

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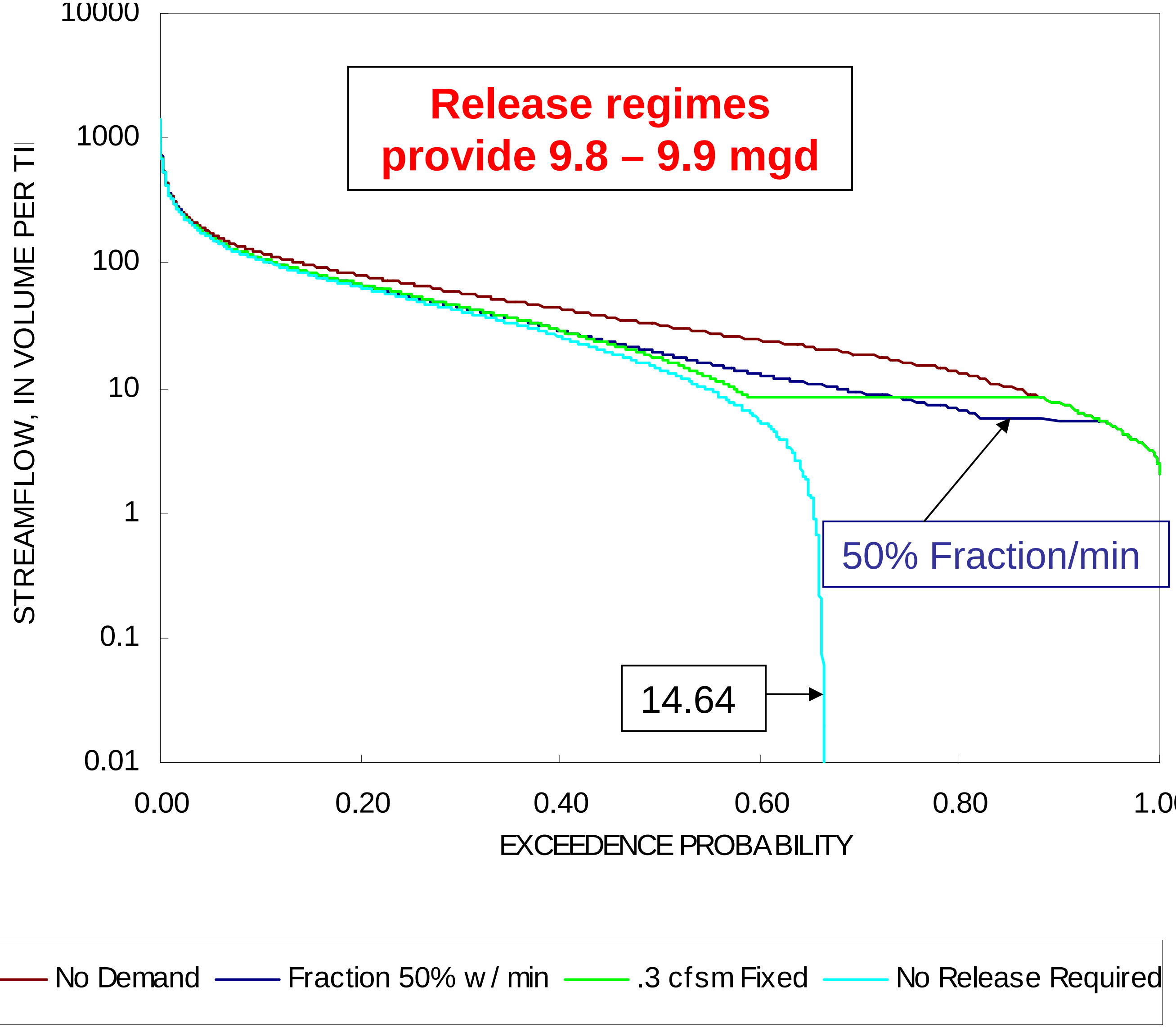
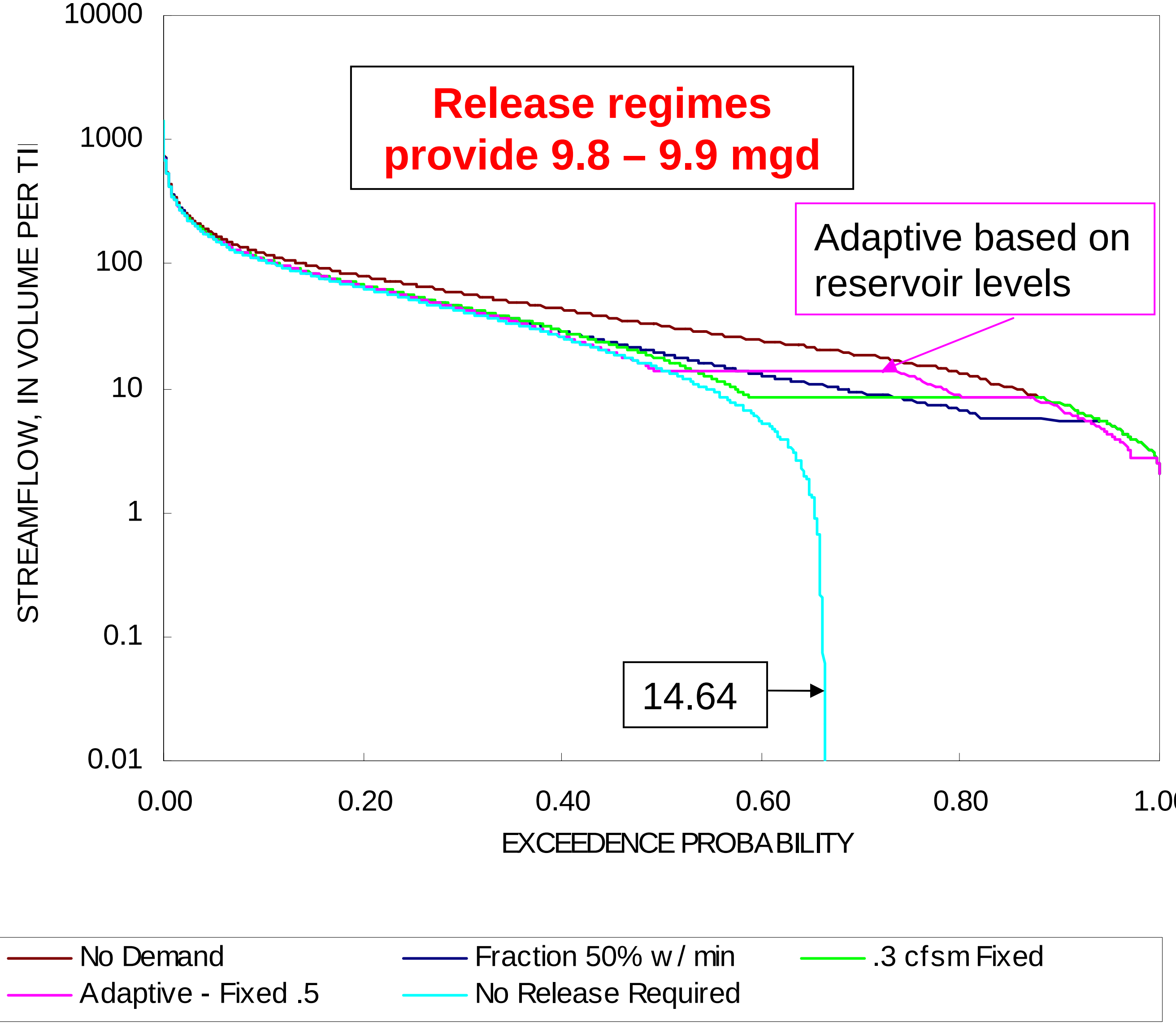


Same Yield but…..
Different Instream Flow Outcomes



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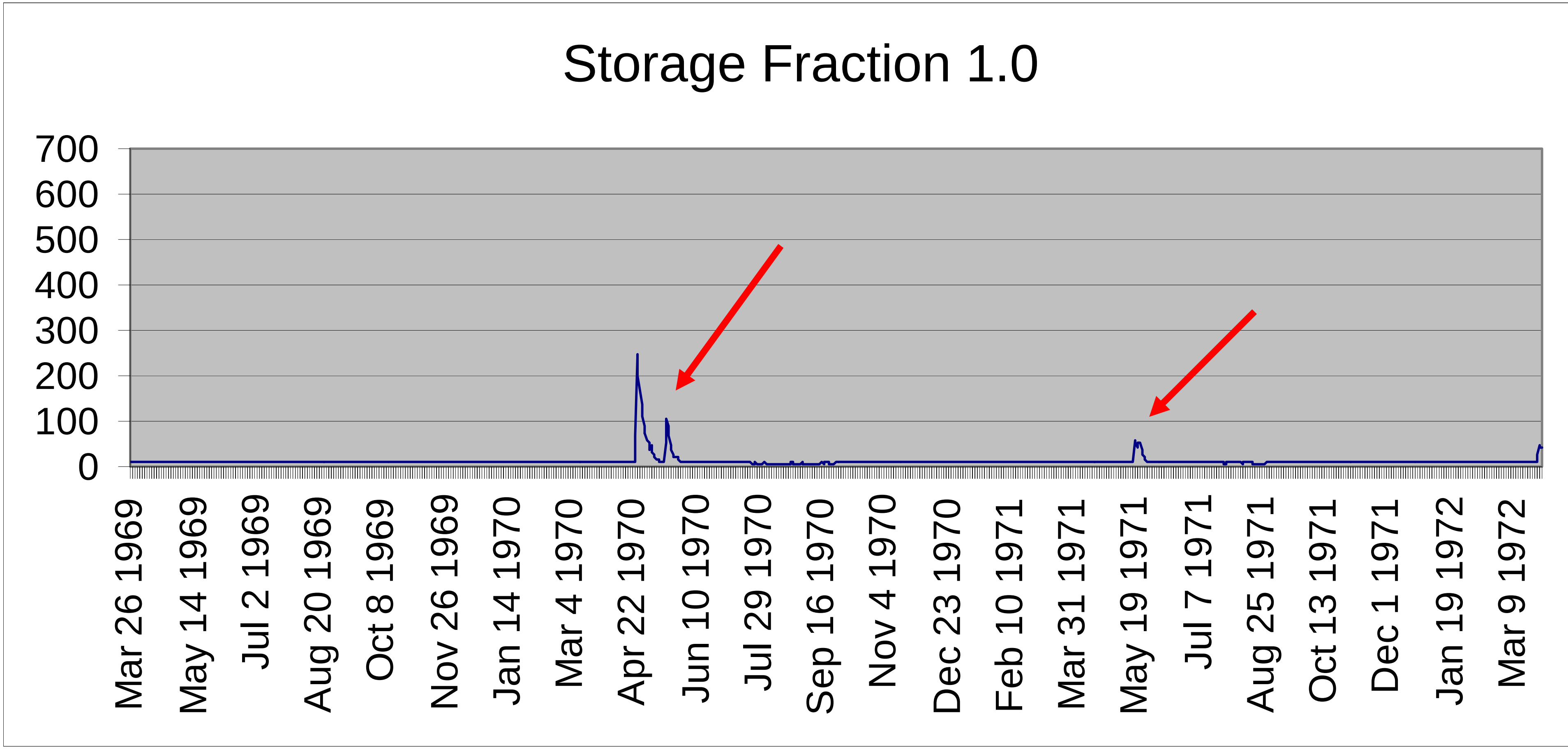
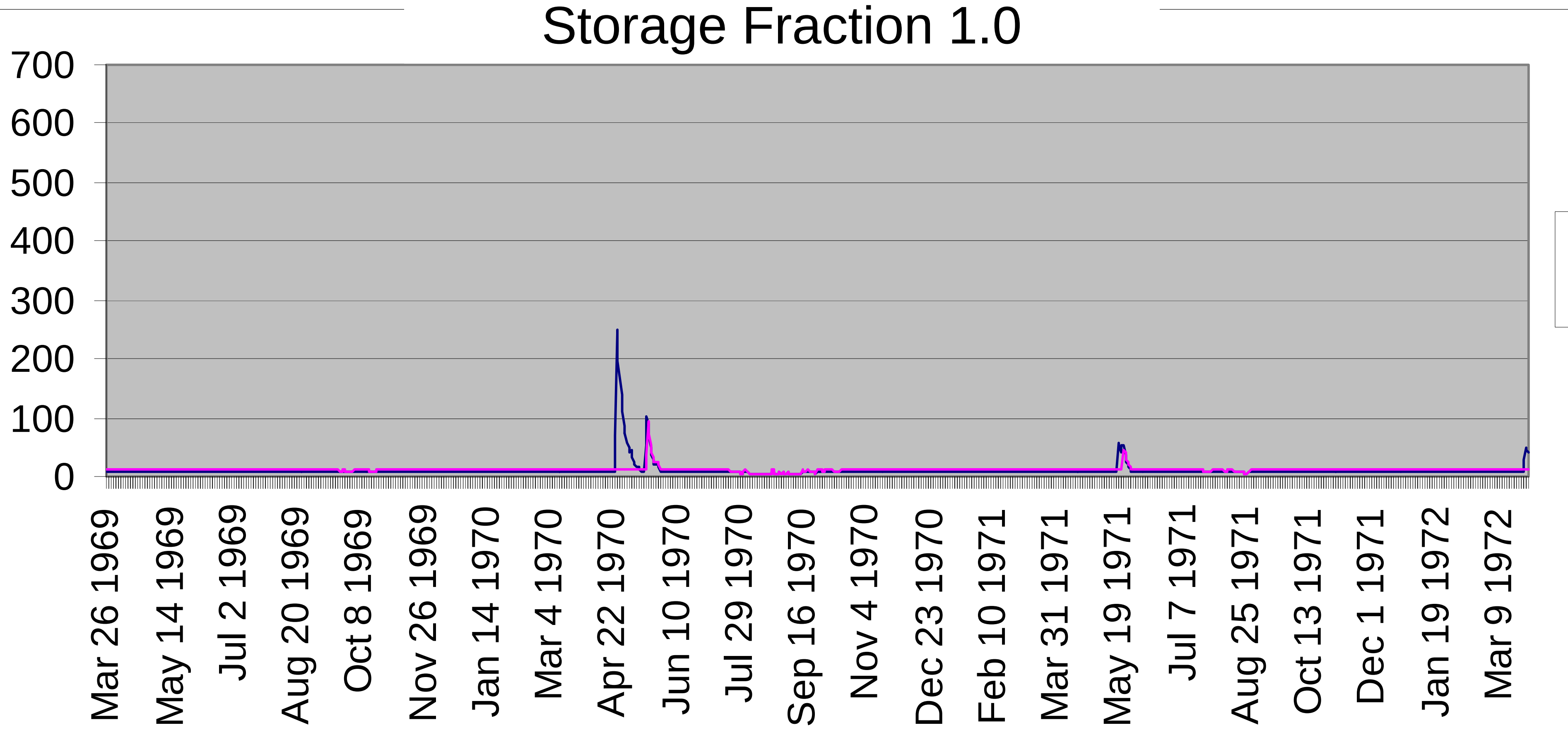
Trade-offs Between Release Policies



.3 cfsm minimum flow

Fixed Minimum Flows reduce number of peaks

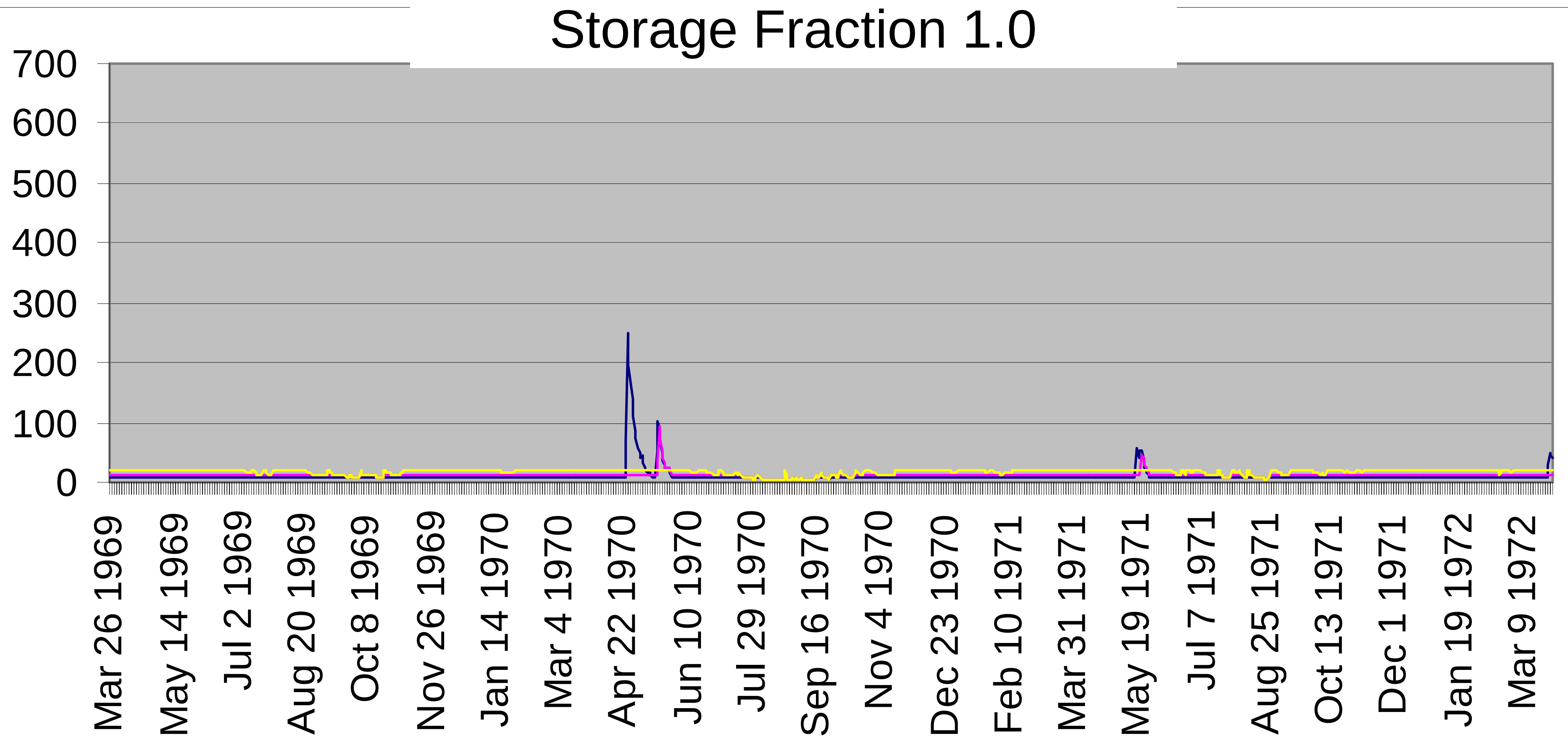
Trade-offs Between Release Policies



.5 cfsm minimum flow

Higher minimum flows = fewer and smaller

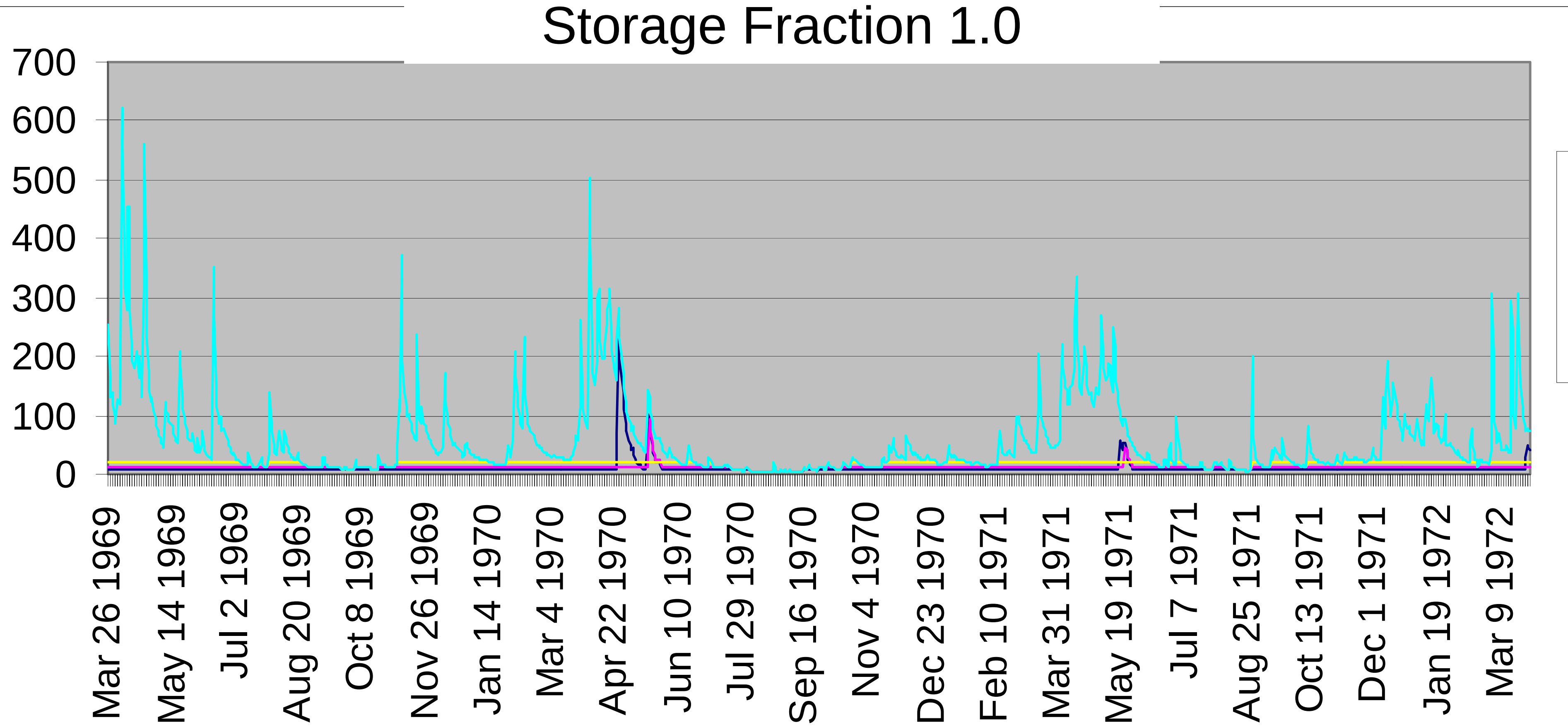
Trade-offs Between Release Policies



.7 cfsm minimum flow

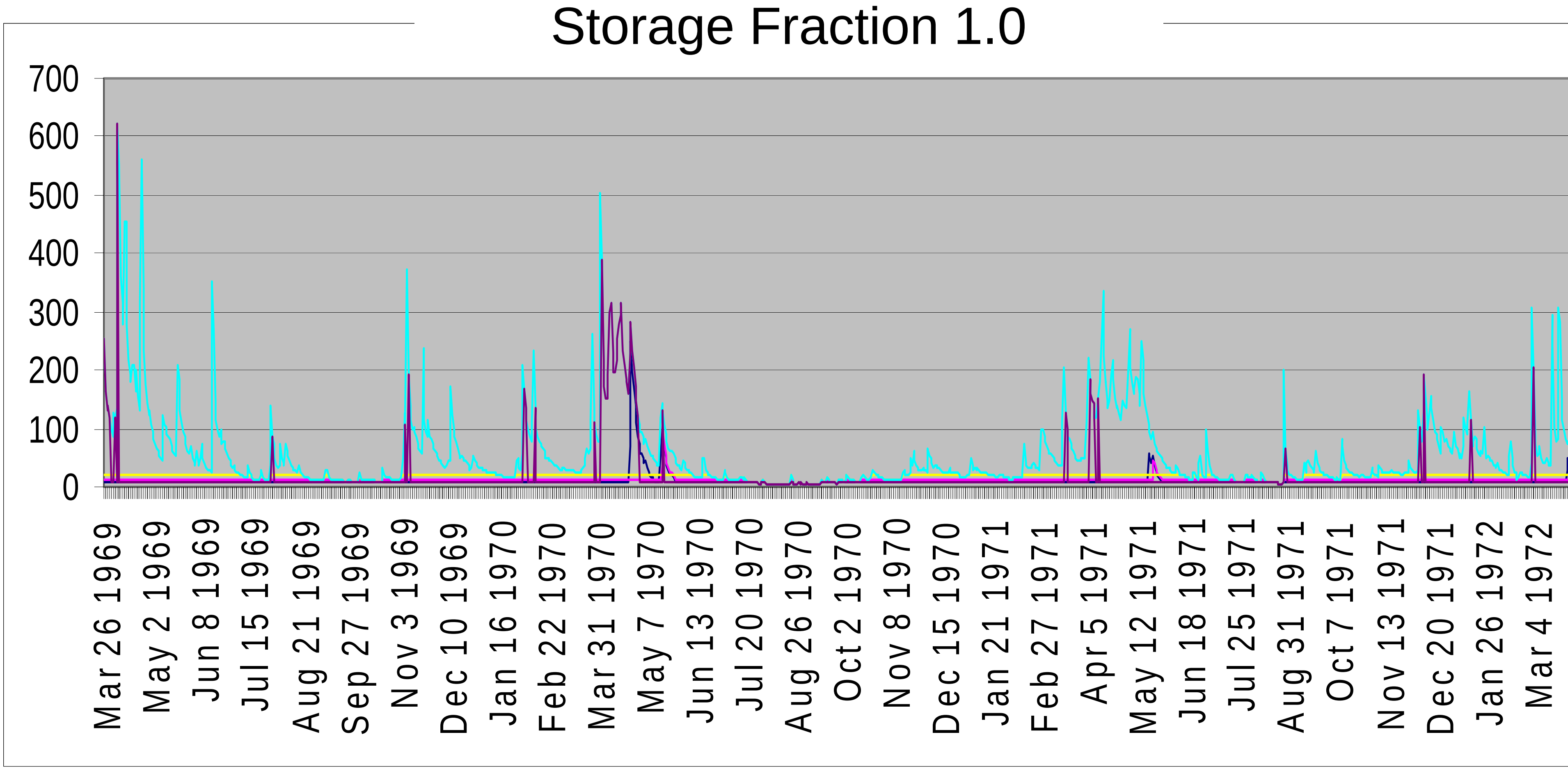
Higher minimum flows = can eliminate many

Trade-offs Between Release Policies



Especially compared to natural flow regimes

Trade-offs Between Release Policies



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

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As a result of CNS support we…………

NCER STAR Science to Achieve Results

- 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

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Funding Provided By:

U.S. Environmental Protection Agency

Collaborative Science and Technology Network for Sustainability

EPA Grant # X3-83238601-0

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