



# Integrating Water Supply And Ecological Flow Requirements

EPA Grant # X3-83238601-0

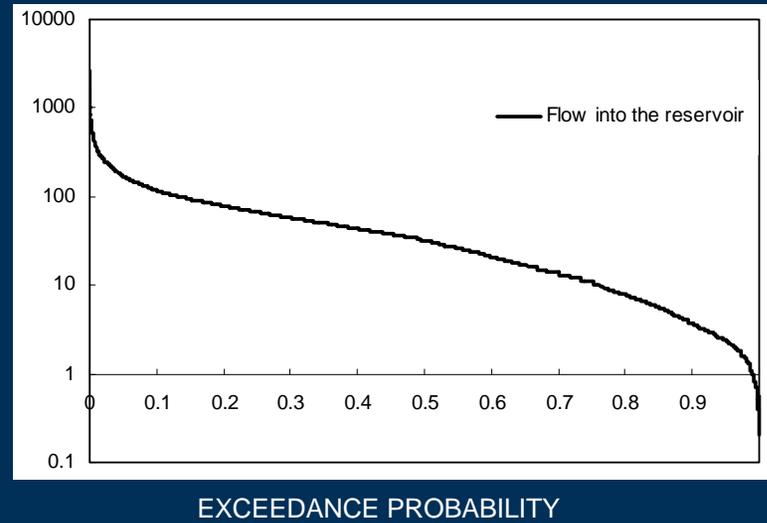
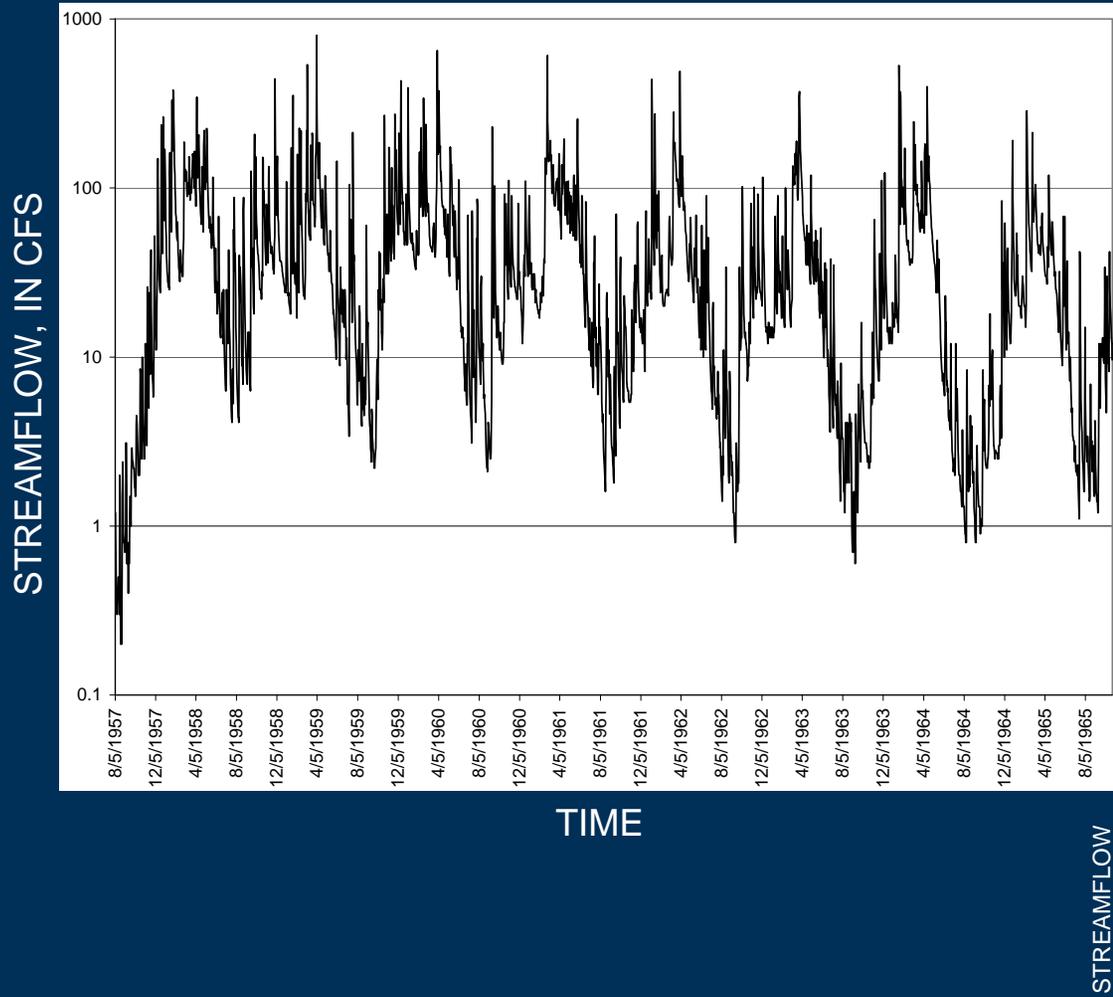
**Collaborative Science and Technology  
Network for Sustainability Workshop**

**Washington, DC  
November 8-9, 2007**

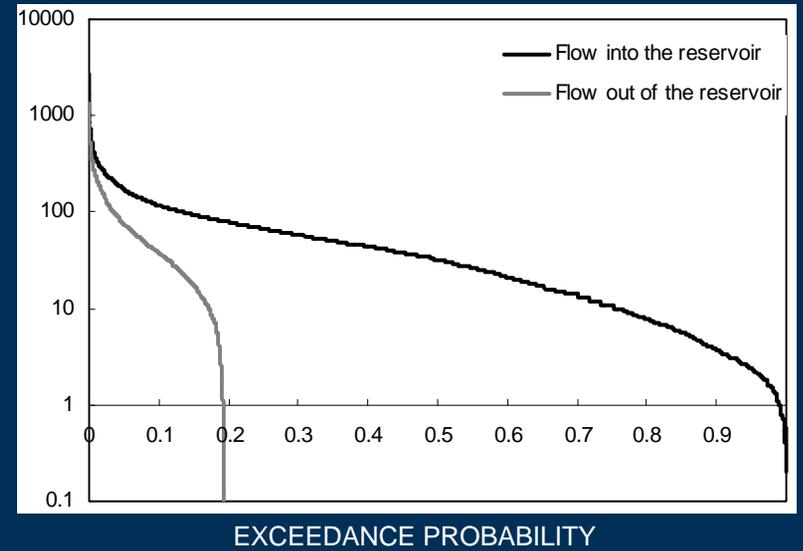
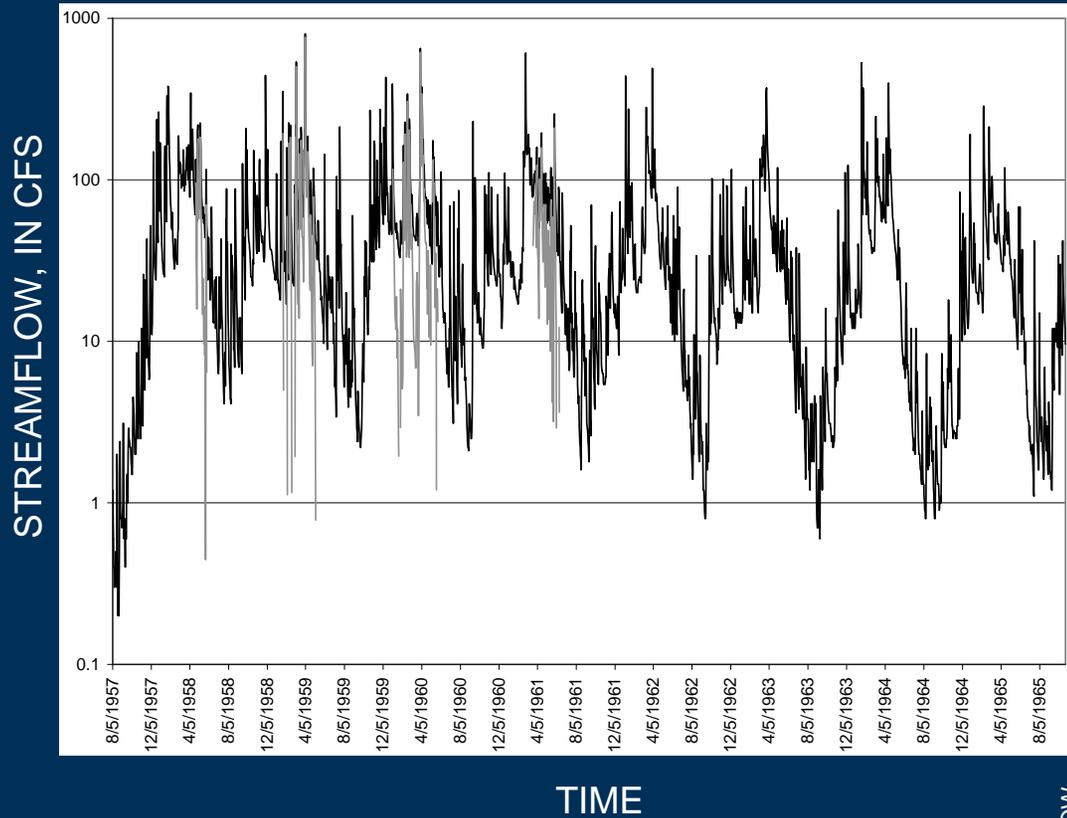
# Experiment Objectives

- Examine trade-offs between human and ecological demands for water for a wide range of reservoir-release policies and reservoir sizes
- Quantify effects of demand management on this tradeoff
- Apply results to real-world case studies
- Communicate results through publication

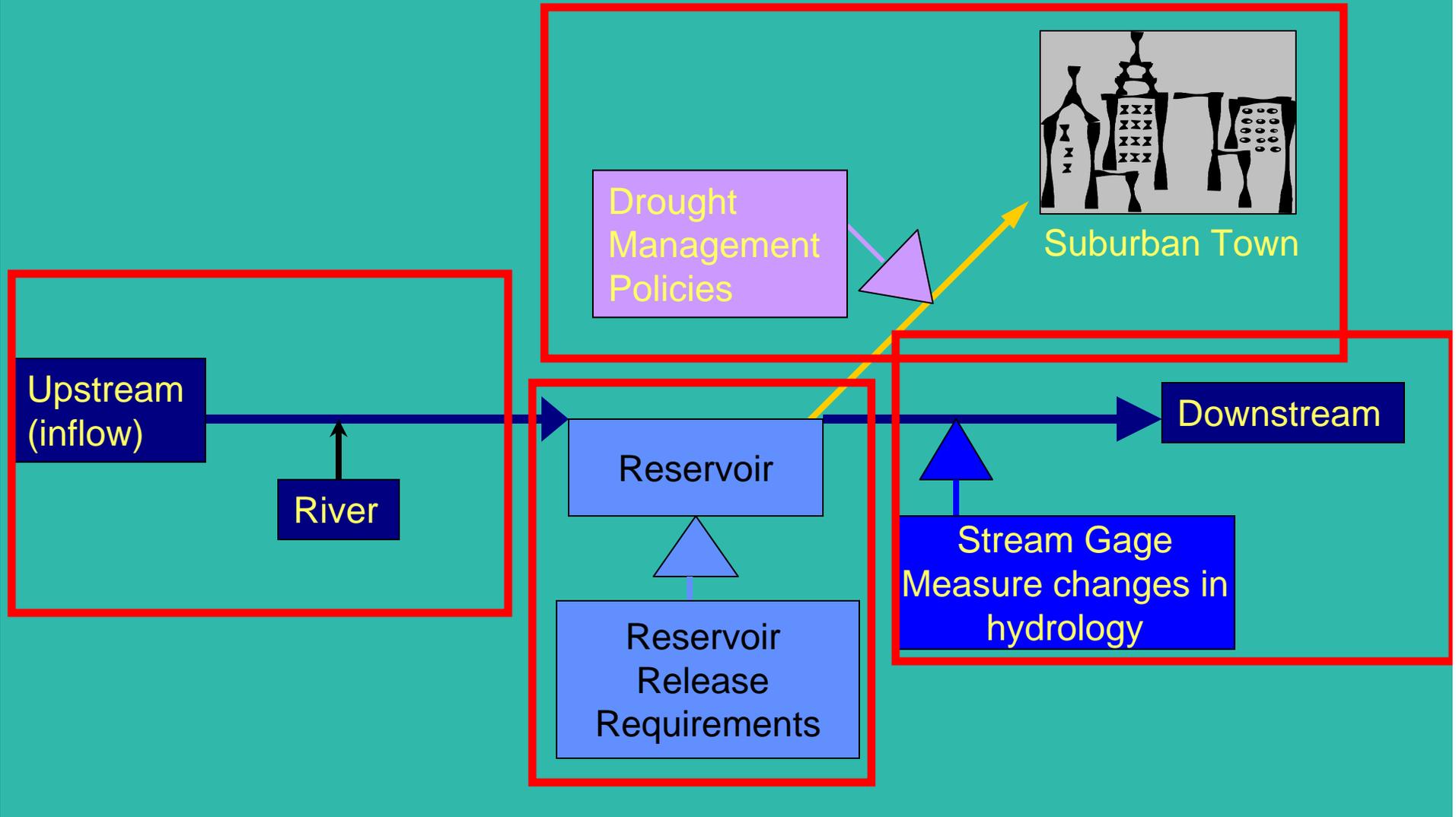
# Inflows to the reservoir



# Downstream Flow with No Release Required



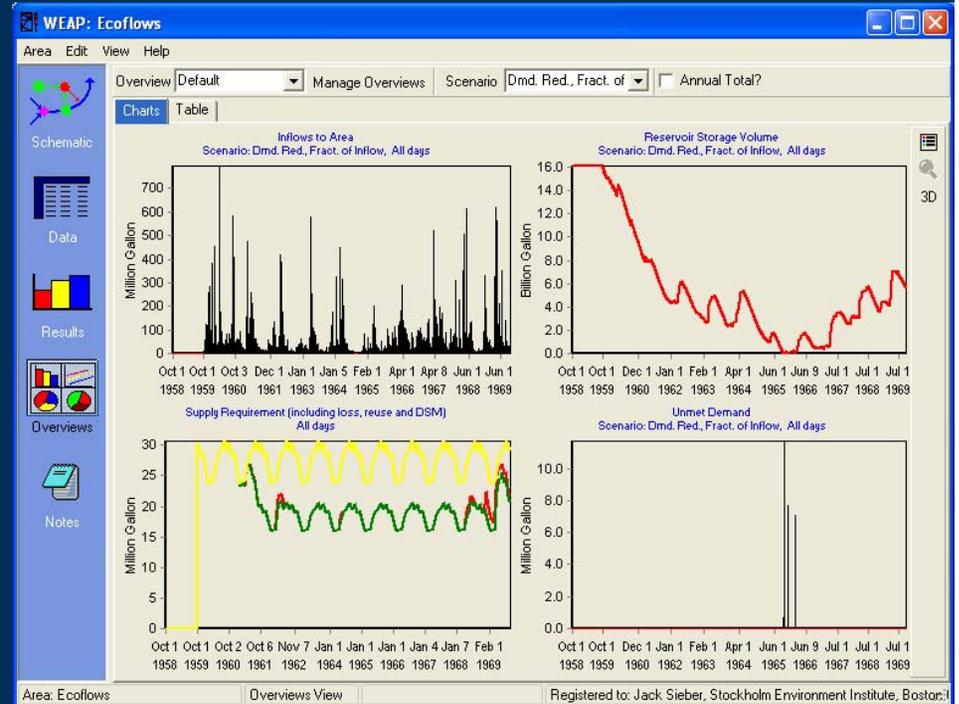
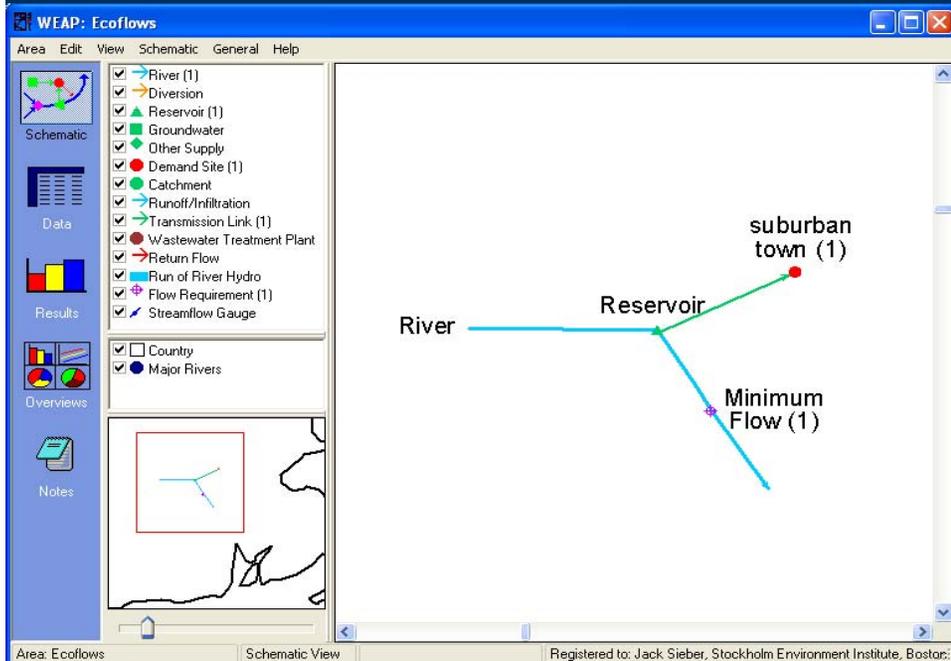
# Model Overview



# Model Platform

## Water Evaluation and Planning model (WEAP)

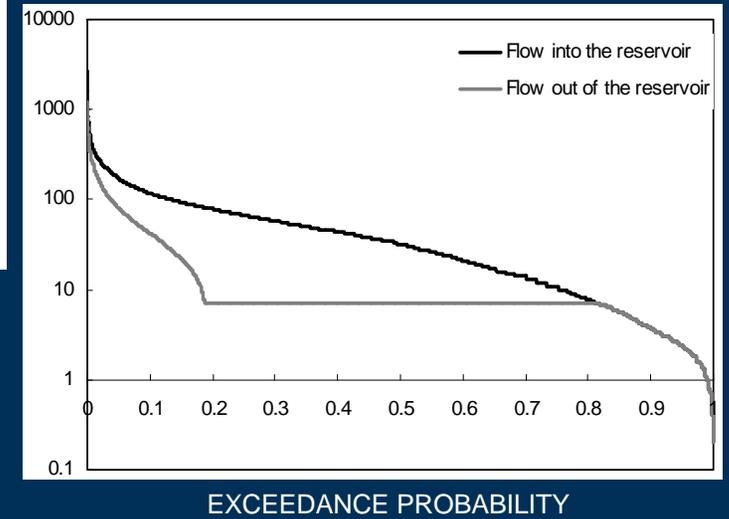
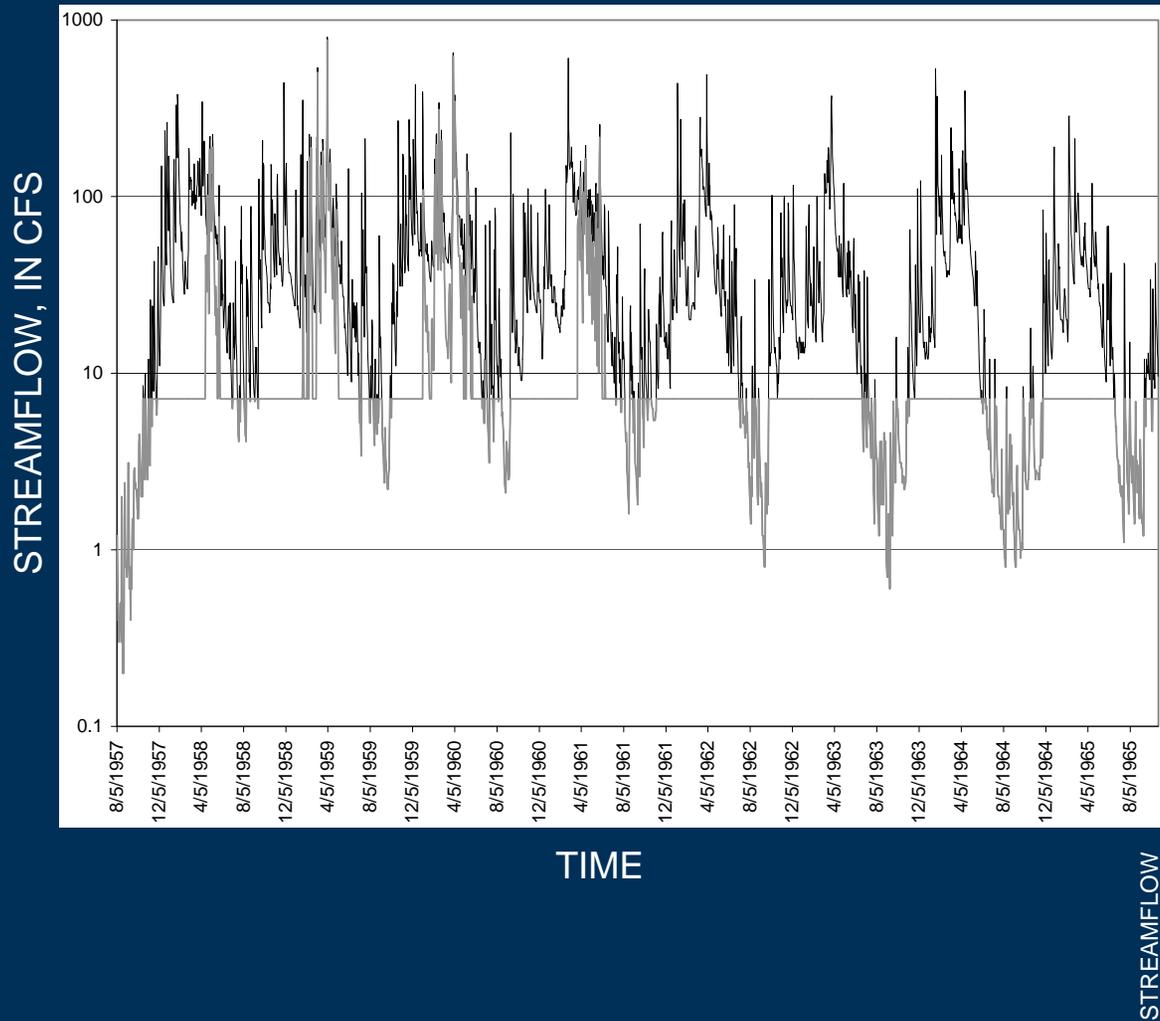
- Developed by Stockholm Environment Institute



# Release Policies Simulated

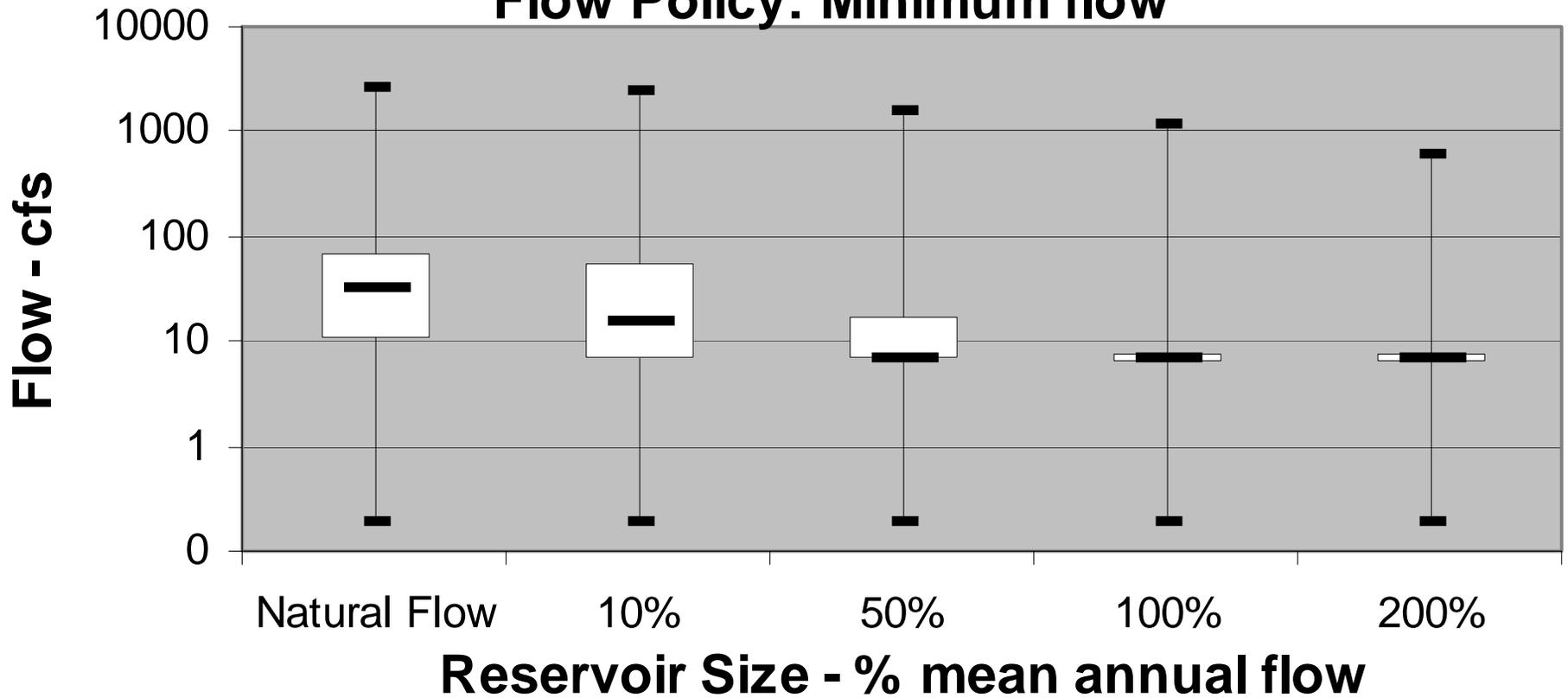
- No Release Required
- Minimum flows
- Seasonal minimum flows
- Seasonal minimum flows with high pulses
- Adaptive seasonal minimum flows
  - based on reservoir level
- Fraction of inflow
- Fraction on inflow with low flow protection

# Flow Policy: Minimum release

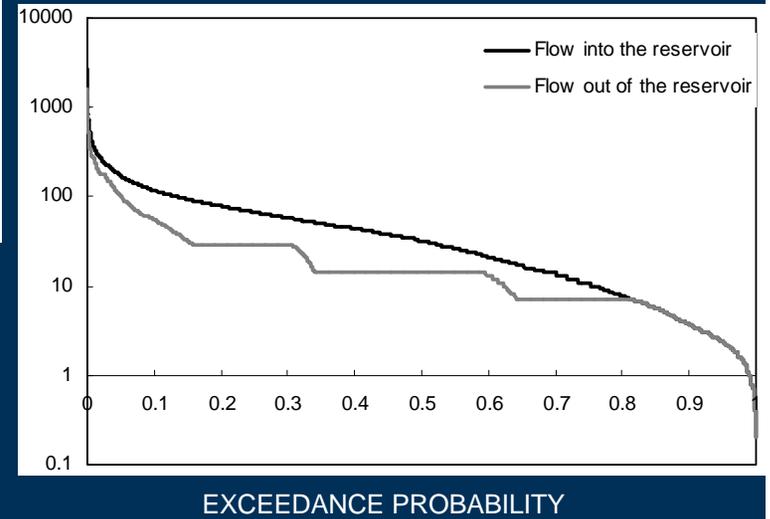
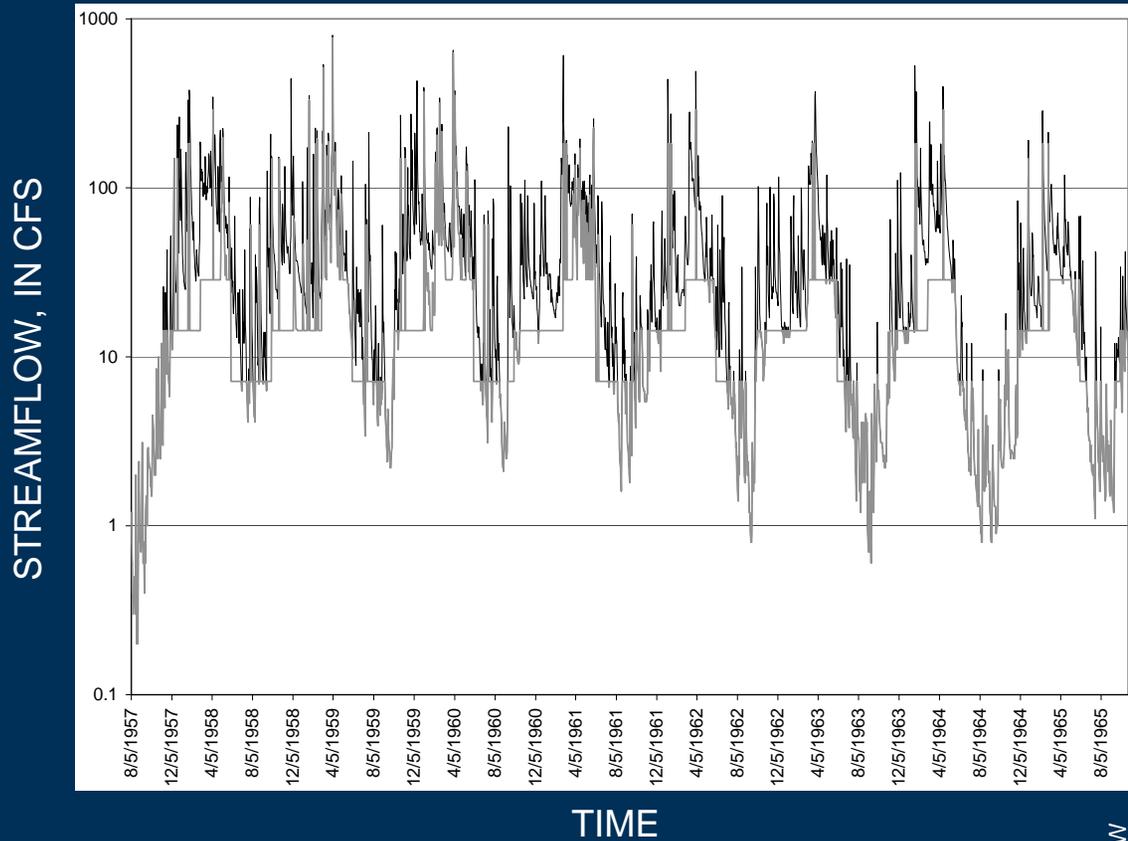


# Reservoir Size

## Flow Variability Below Reservoirs Flow Policy: Minimum flow



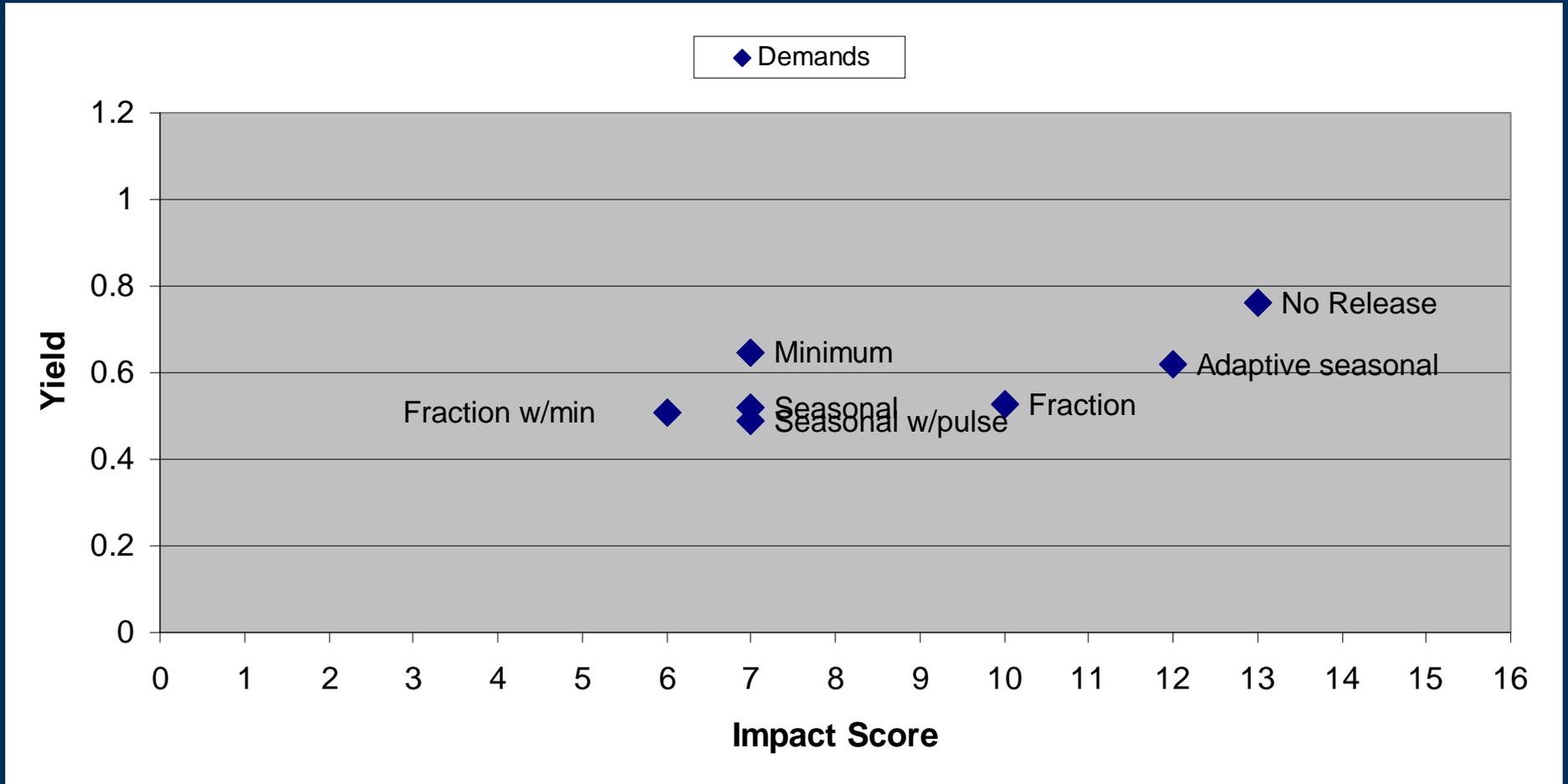
# Flow Policy: Seasonal min with pulses



# Flow Alteration Metrics

Flow statistic	# Days Pre (avg/yr)	# Days Post (avg/yr)	Change (percent)	Impact Score range	Score
<b>High Flows</b>					
≥ 0.02	7.3	2.4	-66.6%	0 – 3	2
≥ 0.10	37.1	10.4	-72.1%	0 – 3	2
<b>Mid Flows</b>					
≤ 30% MAF	120.9	315.4	155.3%	0 – 3	3
<b>Low Flows</b>					
≤ 0.90	36.5	296.9	712%	0 – 3	3
≤ 0.98	7.3	295.4	3903%	0 – 3	3
<b>Total</b>				<b>0 - 15</b>	<b>13</b>

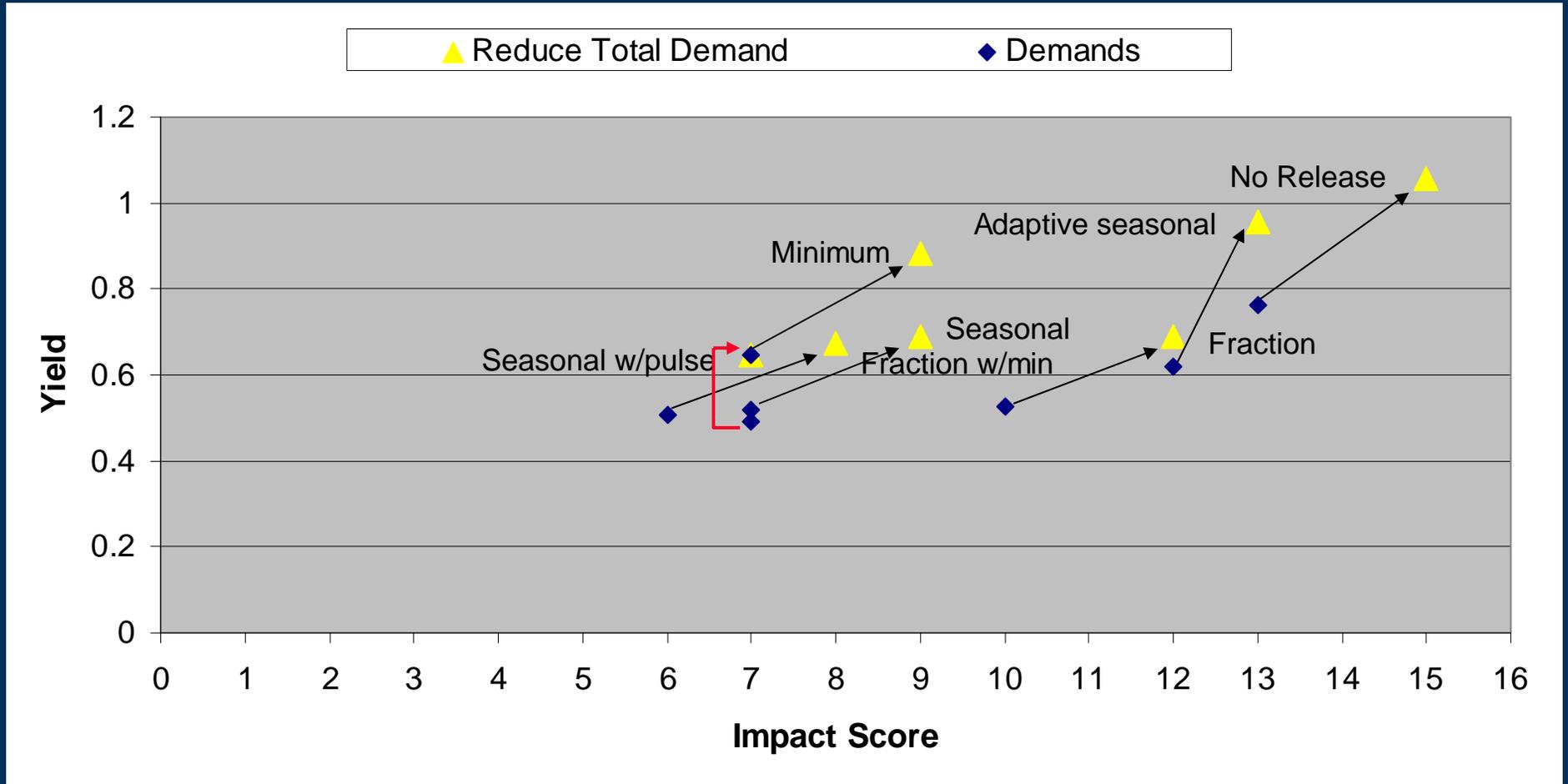
# Yield and Impacts



# Drought Management Policies

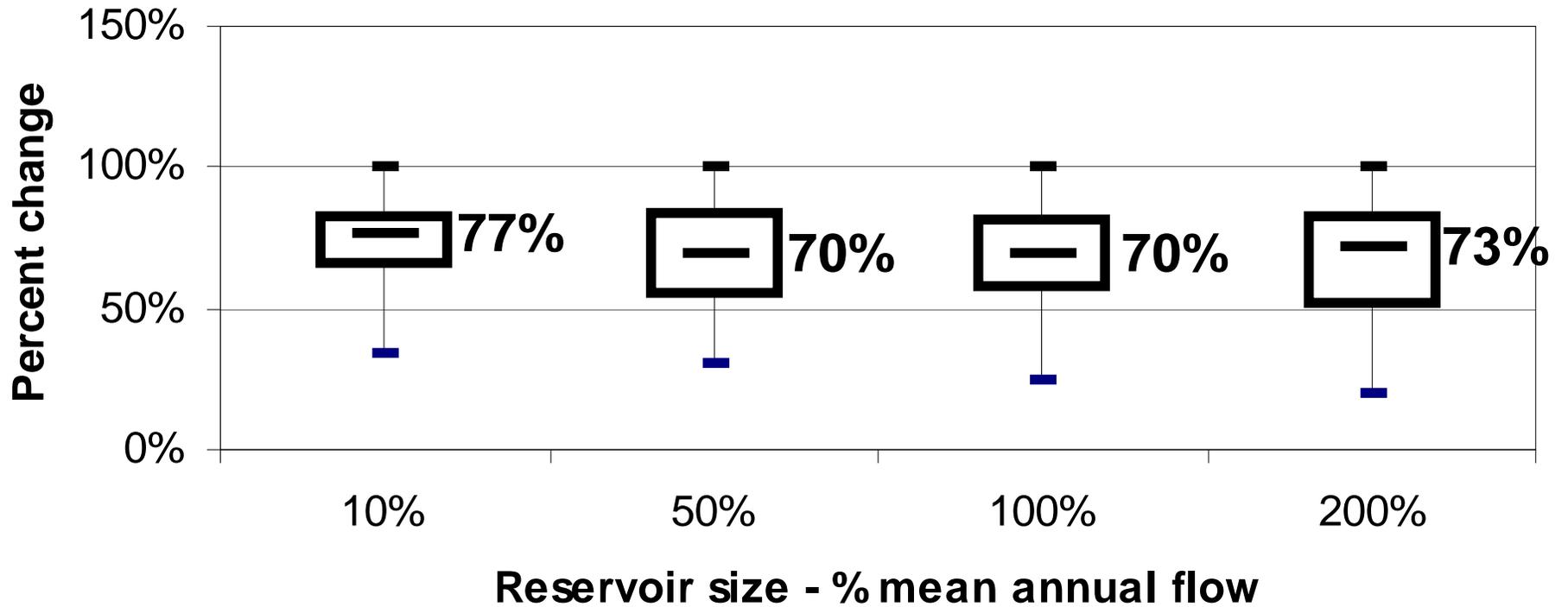
Reservoir Level (% full)	Demand Reduction
60-100%	0
40-59%	20%
0-39%	40%

# Yield and Impacts Drought Management



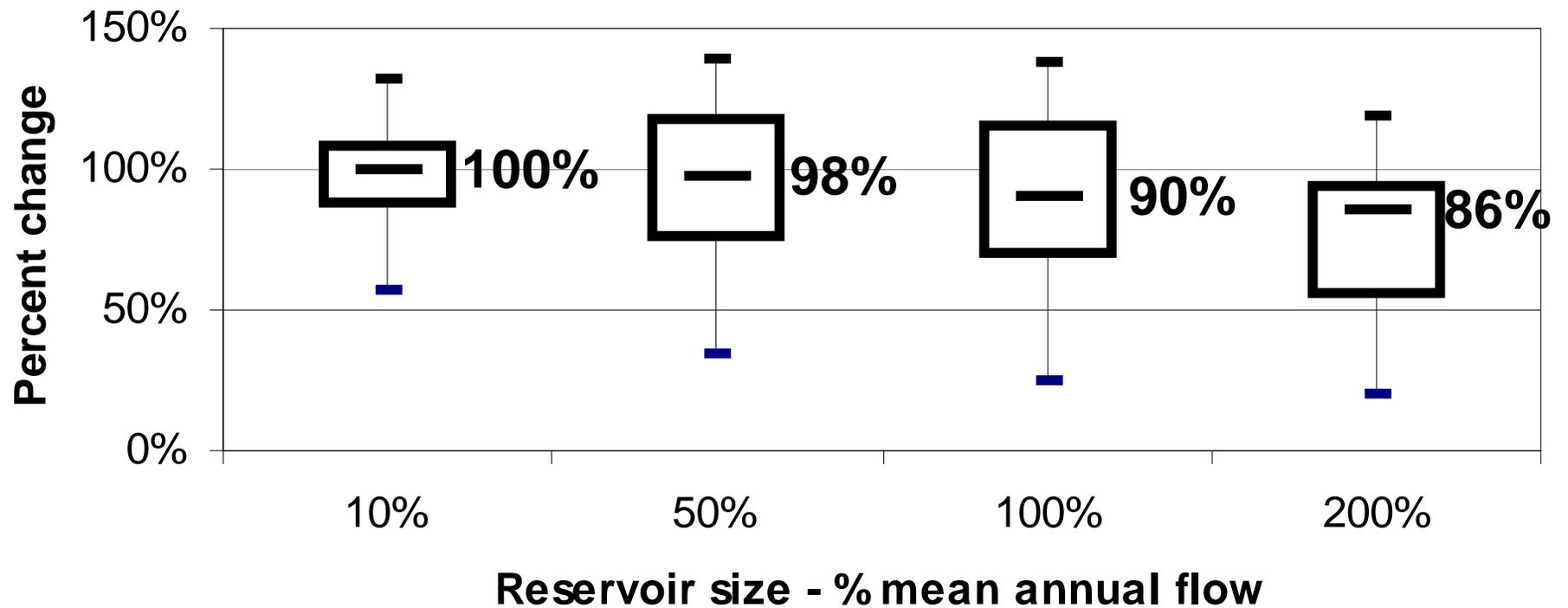
# Release rules can reduce reservoir yields by 24-30%

% Change from No Release



# Drought management can allow for comparable yields to no releases

## % Change from No Release - Drought mgmt

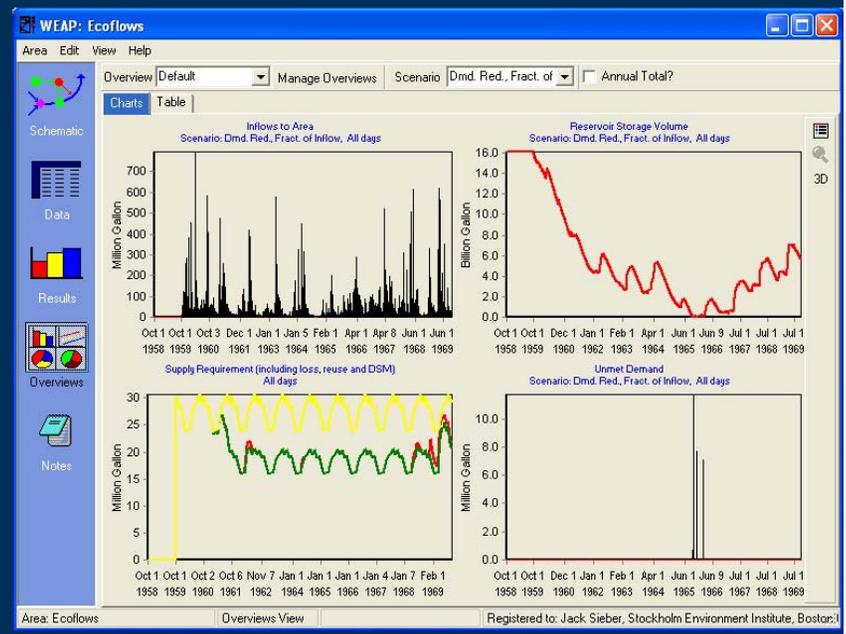
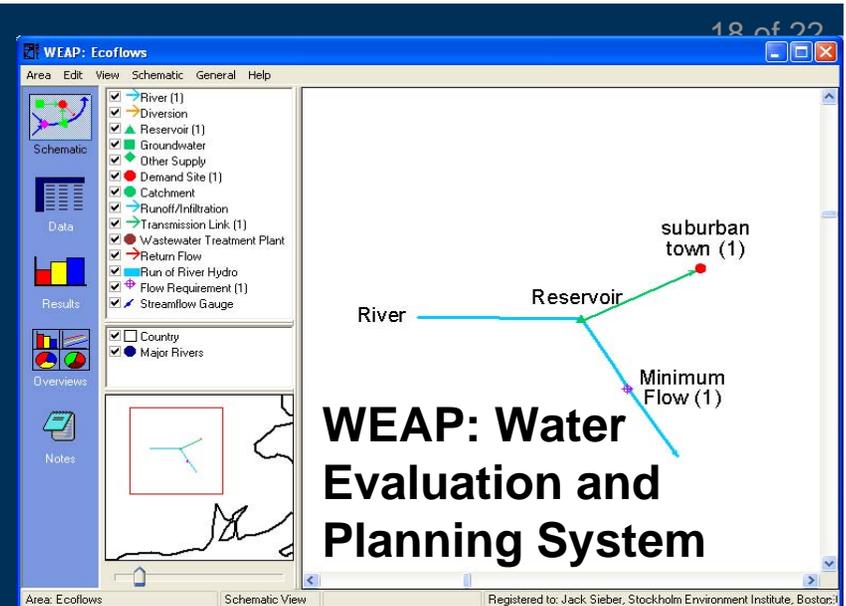


# Results and Lessons Learned

- Environmental sustainability of water supplies can be improved through the use of integrated reservoir release policies and drought policies
- Reduced yields as a result of reservoir release policies can be largely offset by drought management measures:
  - Release rules can reduce reservoir yields by 24-30%
  - Drought management can allow for yields comparable to no-release yields and pre-reservoir flow conditions
- Increased supplies from drought management can be used to support environmental flows
- Release policies that are effective for small reservoirs may not be effective for large reservoirs

# Project Collaboration

- Case study in support of Connecticut Department of Environmental Protection's effort to develop a streamflow-protection regulation
- Tool will be used to: a) evaluate draft reservoir release and direct withdrawals policies (standards), and b) be compared to a similar but less robust model being developed by CT Institute for Water Resources



# Response to feedback

- We are starting to apply our results to case studies; therefore, we have just begun to receive feedback from partners in a specific way
- We also have received strong interest in this tool from state-agency personnel in the New England states

# Ways in which CNS funding has helped

- CNS funding has enabled our research team to communicate results through publication and at conferences and workshops around the world:
  - American Society of Civil Engineers, World Environmental and Water Resources Congress (Anchorage, AK)
  - National Center for Environmental Research Subcommittee on Water Availability and Quality (Arlington, VA)
  - International River *Symposium* and Environmental Flows Conference (Brisbane, Australia)
  - EPA Region I Science Day (Boston, MA)
    - Presentation was direct result of being posted on the website
  - American Water Resources Association, Baltimore, MD
  - Article in American Water Works Association journal (October, 2007)

# Future Work

- Apply results to case studies
- Continue evaluation of tradeoffs between reservoir-release policies, reservoir yield and drought management
- Formulate optimization by determining a set of streamflow statistics most representative of change in the natural-flow regime due to reservoir operation
- Develop decision-support tool to optimize reservoir operations that maximize both human and ecological water needs

# Research Team

- **The Nature Conservancy: Mark P. Smith and Colin A. Apse**
- **Stockholm Environment Institute: Brian Joyce and Jack Sieber**
- **Tufts University: Richard M. Vogel, Stacey A. Archfield, and Yongxuan Gao**

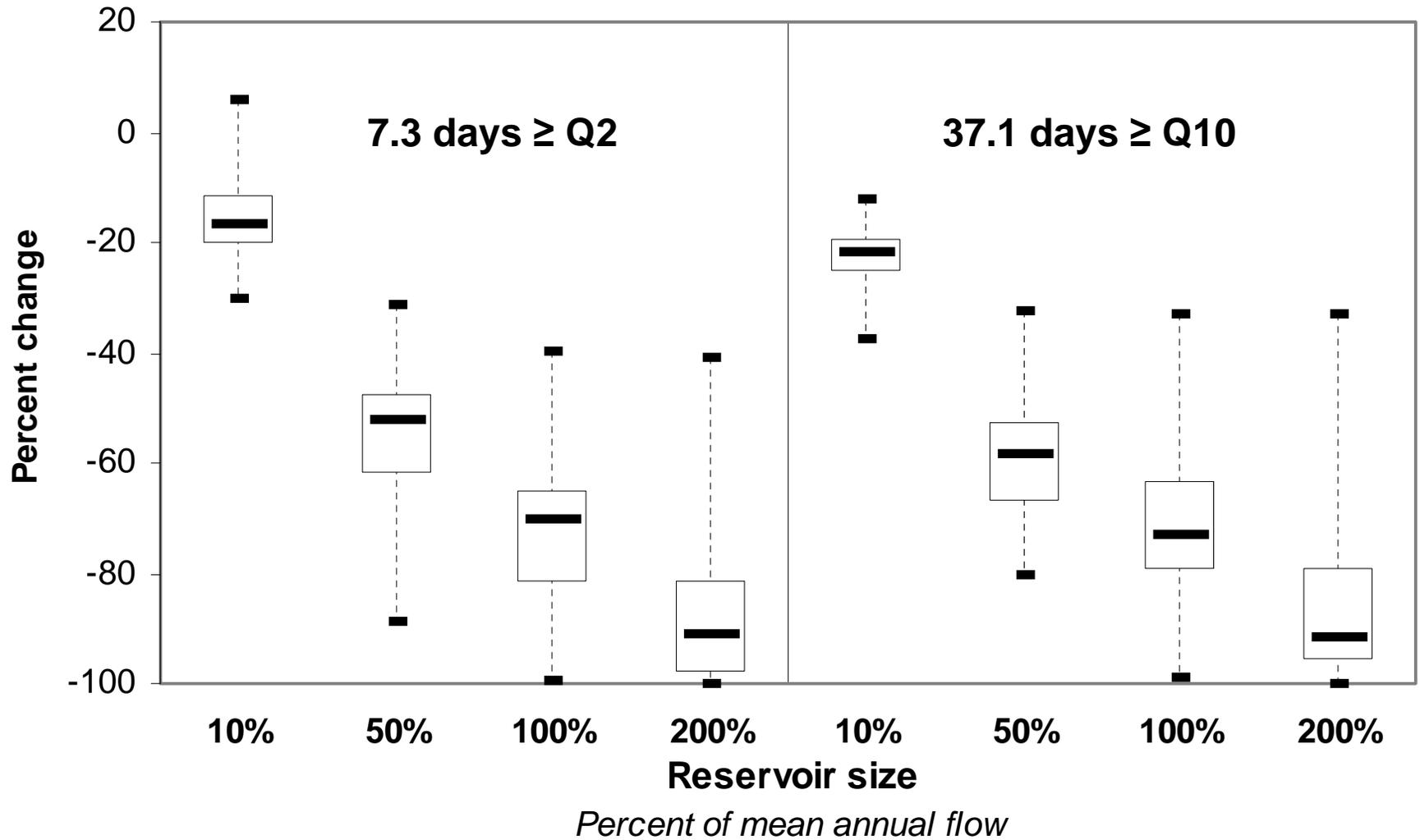


# Meeting the needs of environmental-decision making for sustainability: Project goals

- 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.

# Changes in High Flow Events

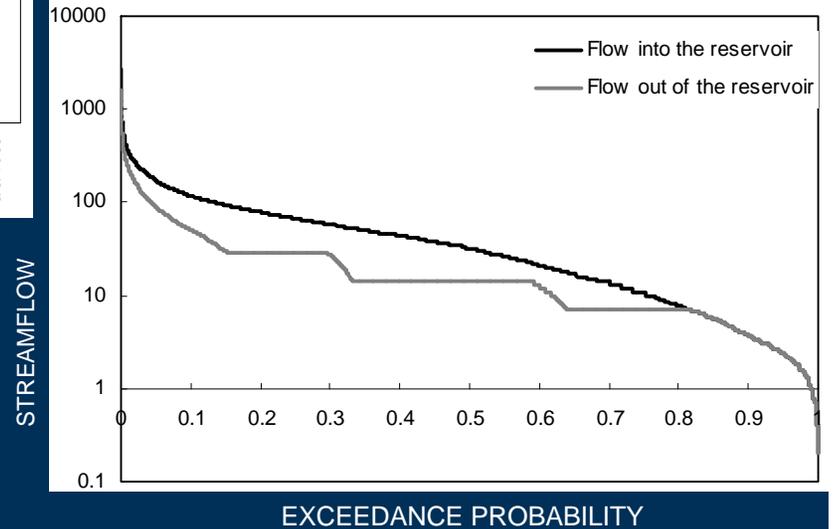
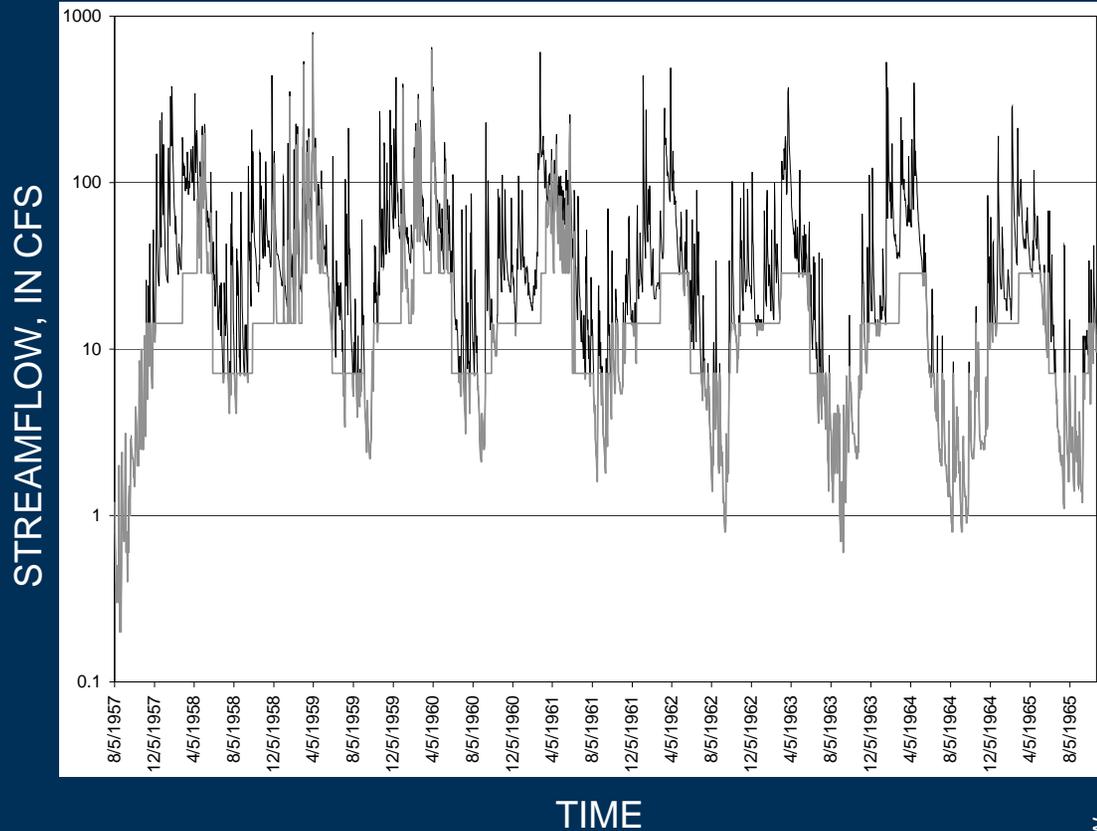
## Change in Days Above Q2 and Q10



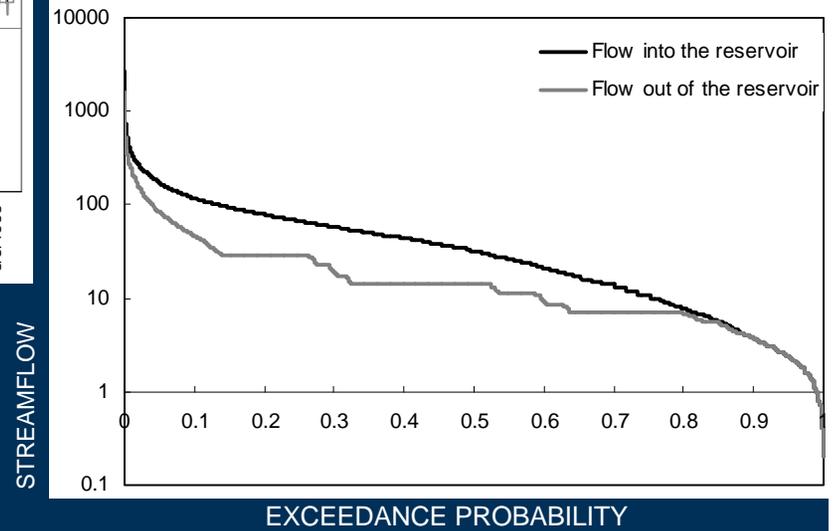
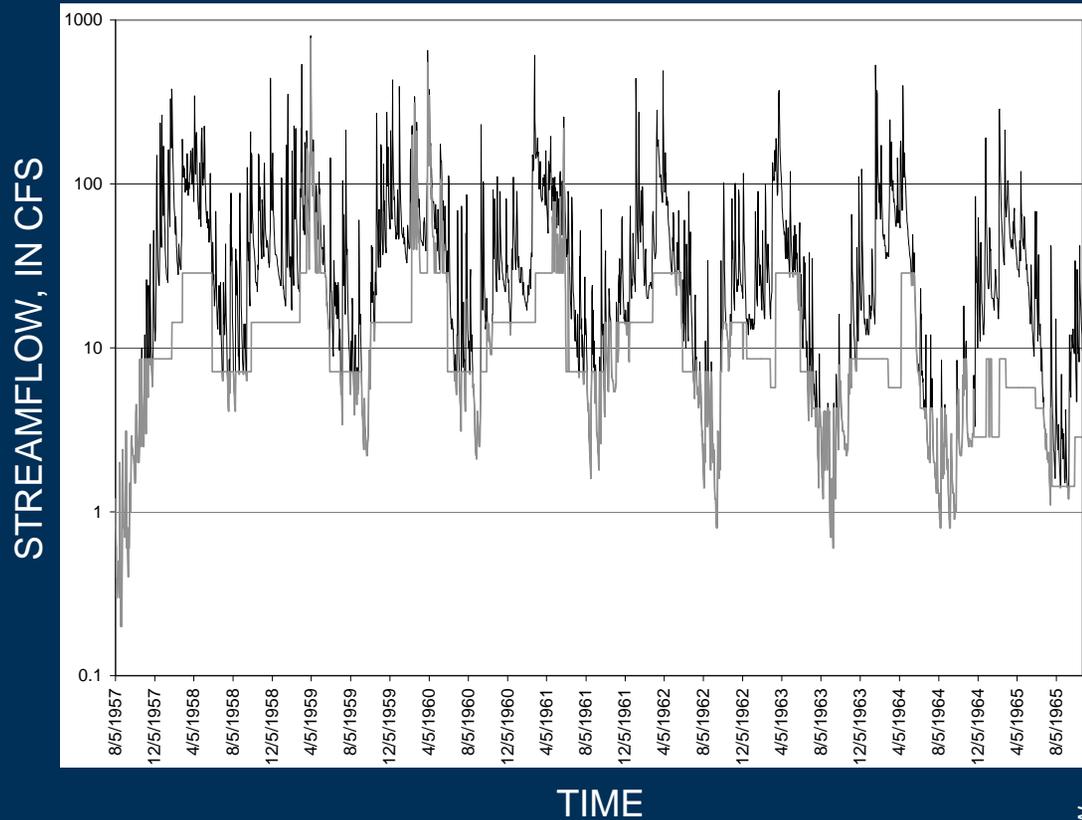
# Reservoir Yields

<u>Policy</u>	<u>Yield Fraction</u>	<u>mgd</u>
■ No Release	0.76	26.5
■ Minimum	0.65	22.4
■ Adaptive seasonal	0.62	21.7
■ Fraction	0.53	18.7
■ Seasonal	0.52	17.7
■ Fraction w/min	0.51	17.0
■ Seasonal w/pulse	0.49	16.4

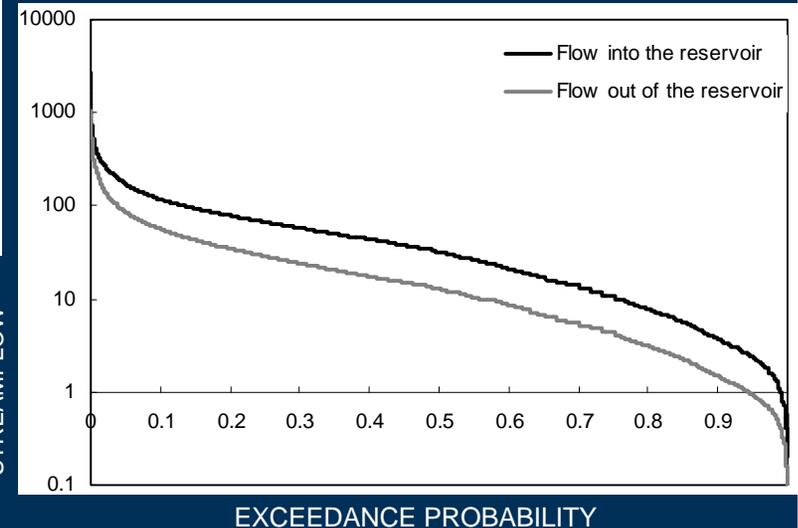
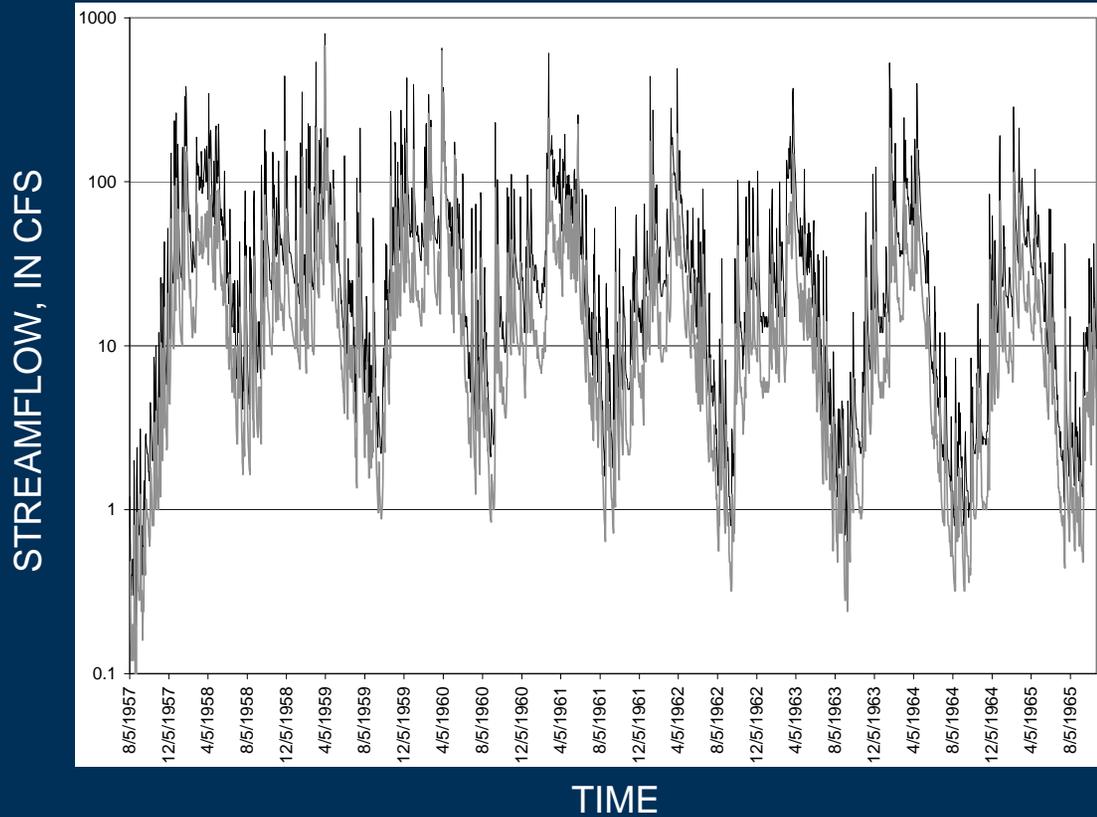
# Flow Policy: Seasonal minimum flows



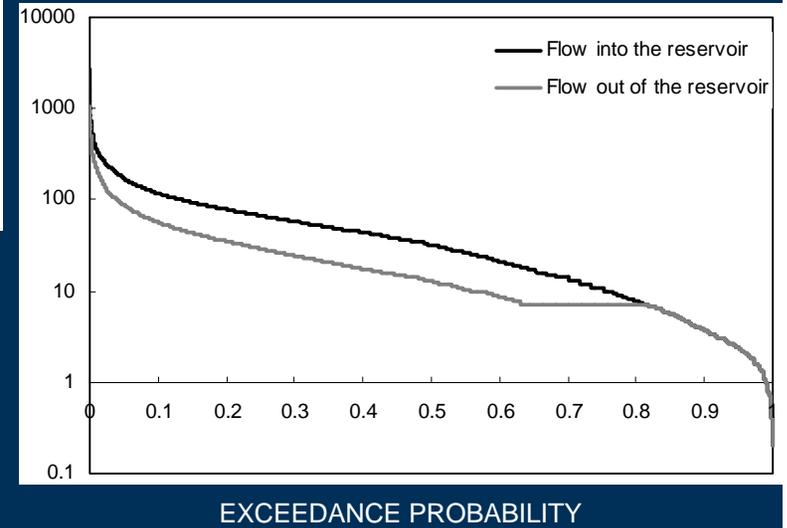
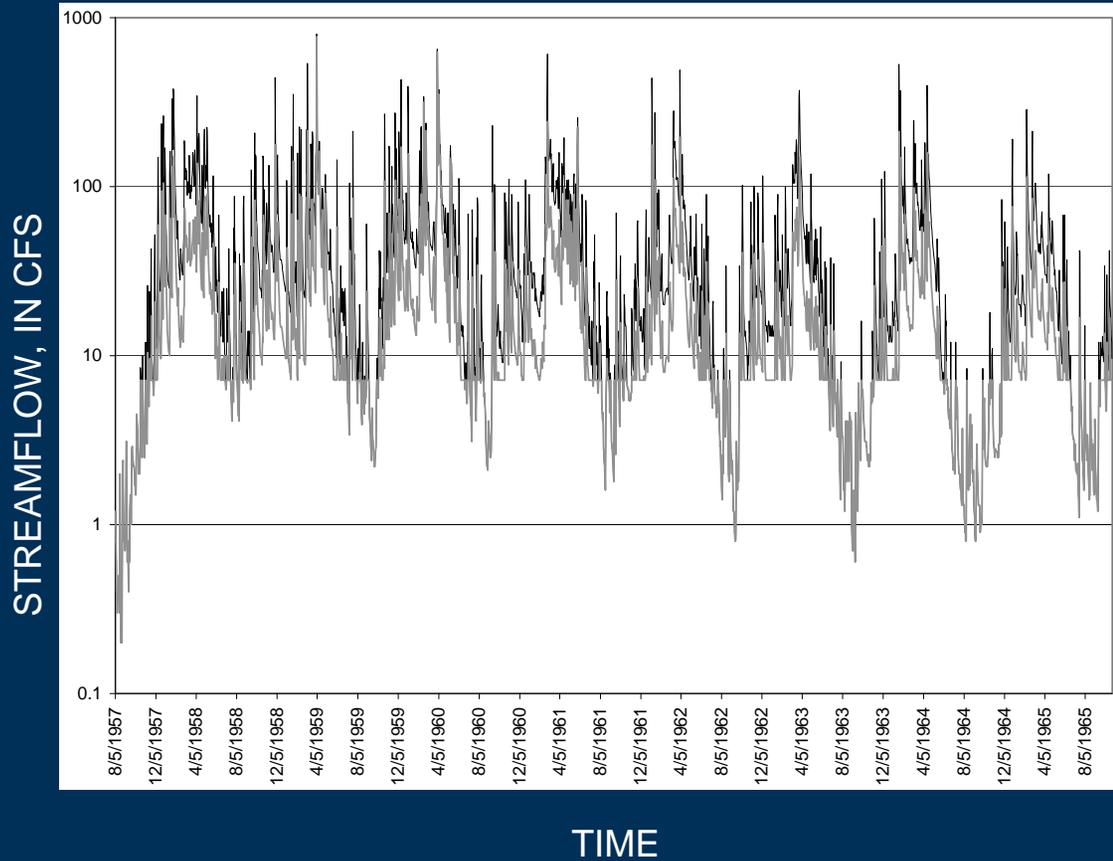
# Flow Policy: Seasonal release based on reservoir level



# Flow Policy: Fraction of inflow

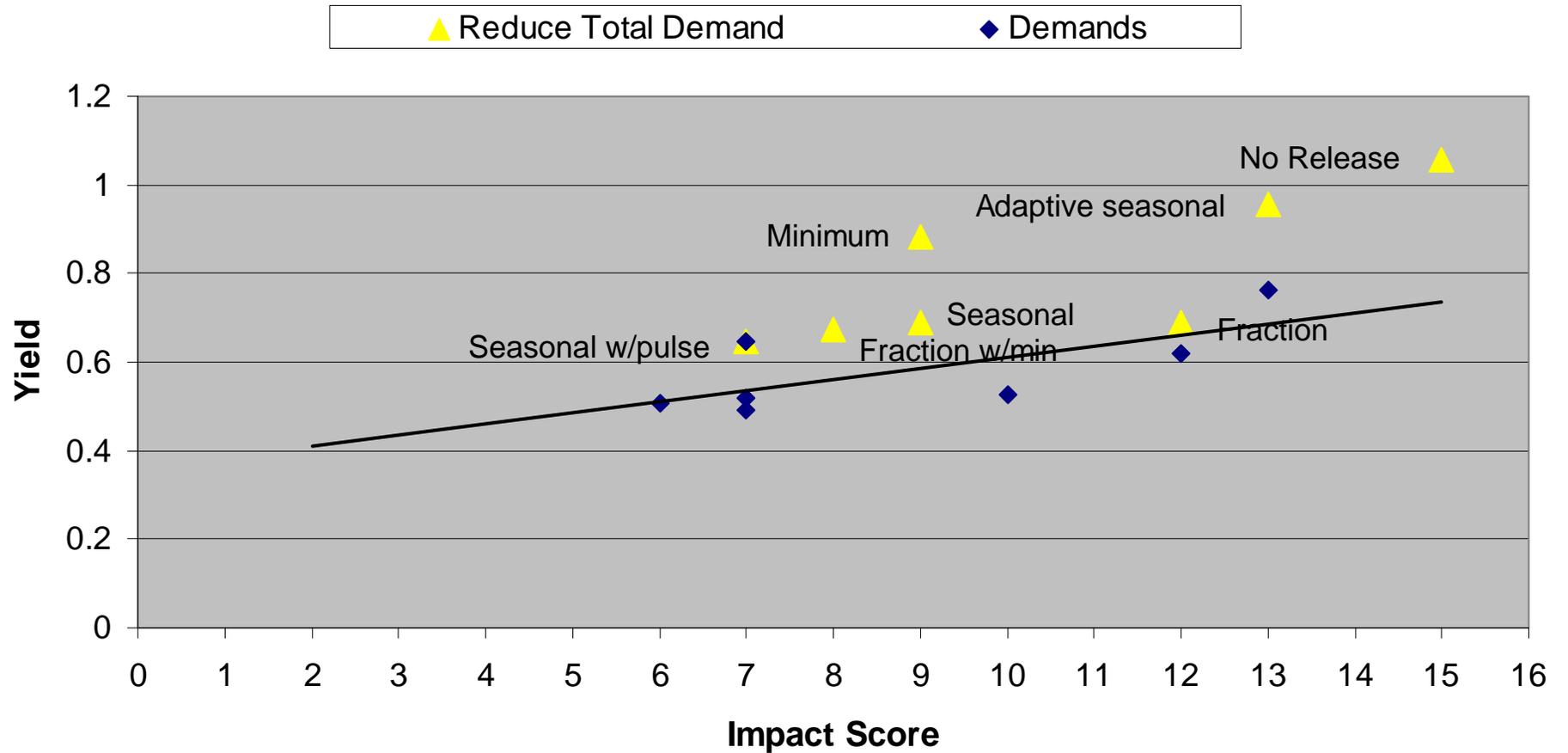


# Flow Policy: Fraction with minimum



# Yield and Impacts

## Yield and Impacts



# Yield and Impacts

## Effects of Drought Management

